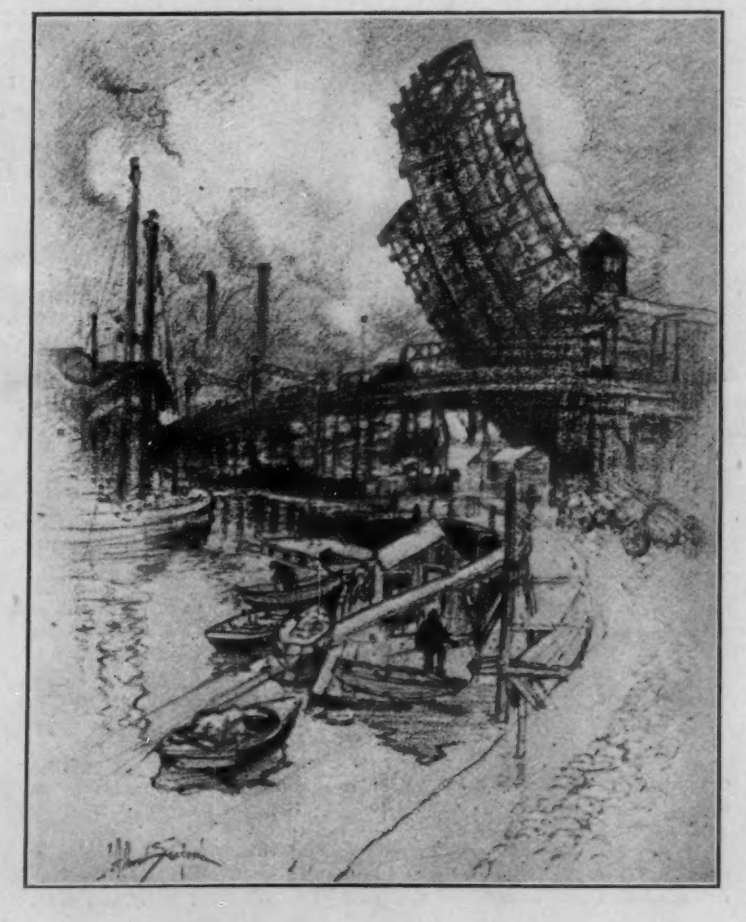
THE TECH ENGINEERING NEWS

MEMBER OF THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED

JAN 12 1927

VOL. VII, No. 6 DECEMBER, 1926



MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASSACHUSETTS

When a bearing goes bad— Lead comes to the rescue

LEAD is a quiet, serious-minded metal which goes about its business without the aid of a press agent and a battery of cheer leaders.

And lead's business is to take an essential part in practically every modern industry. Most often it is the guardian, protecting the weather-beaten structures of buildings, sheathing the wires that carry power and light to every home, every factory.

Production of an entire plant may be seriously interrupted when one bearing on a single machine goes bad. What is the remedy? Lead. Not lead alone—it is perfectly willing to work with other metals to form babbitt alloys that are stronger, more durable, more dependable than any leadless bearing metal.

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Eagle Babbitt Service gives him the answer. For Eagle-Picher research has produced three different grades of bearing metal which are designed scientifically to fill 95% of all babbitt requirements. They are known as Eagle Dreadnaught *High-Speed*, Eagle Outlasta *General Service*, and Eagle Standard No. 4. And Eagle Babbitt Service stands ready to supply special alloys to fill the special needs which industry may develop.

This babbitt service is only one phase of productive research in the Eagle-Picher institution which is constantly on the watch for new uses for lead in all its useful forms. Tomorrow, when industry's developing processes require new services from lead, Eagle-Picher will be ready to supply the need.

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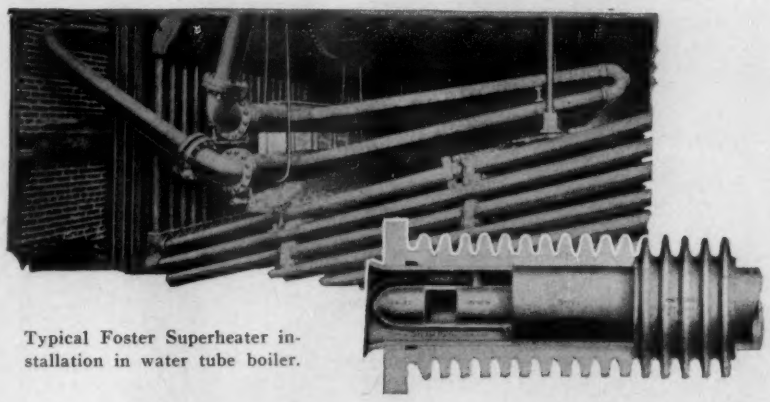
Reducing power costs in every industry



Typical Foster Superheater installation in water tube boiler.

A necessity in the modern power plant

IN these days of steadily-mounting costs of fuel and labor, there is a greater demand than ever before for engineers who can point out tested methods and equipment that will reduce the cost of generating power.

Today, every well-informed engineer knows that a correctly designed superheater will effect a greater fuel saving per dollar invested than any other steam power plant equipment. The unquestioned benefits of superheat to boiler efficiency, engine and turbine economy, and power plant operation, have in large measure been established by the operating records of more than 10,000 Foster superheater installations extending over 20 years of service.

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A few users of Foster Superheaters

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Oil	Standard Oil Co.
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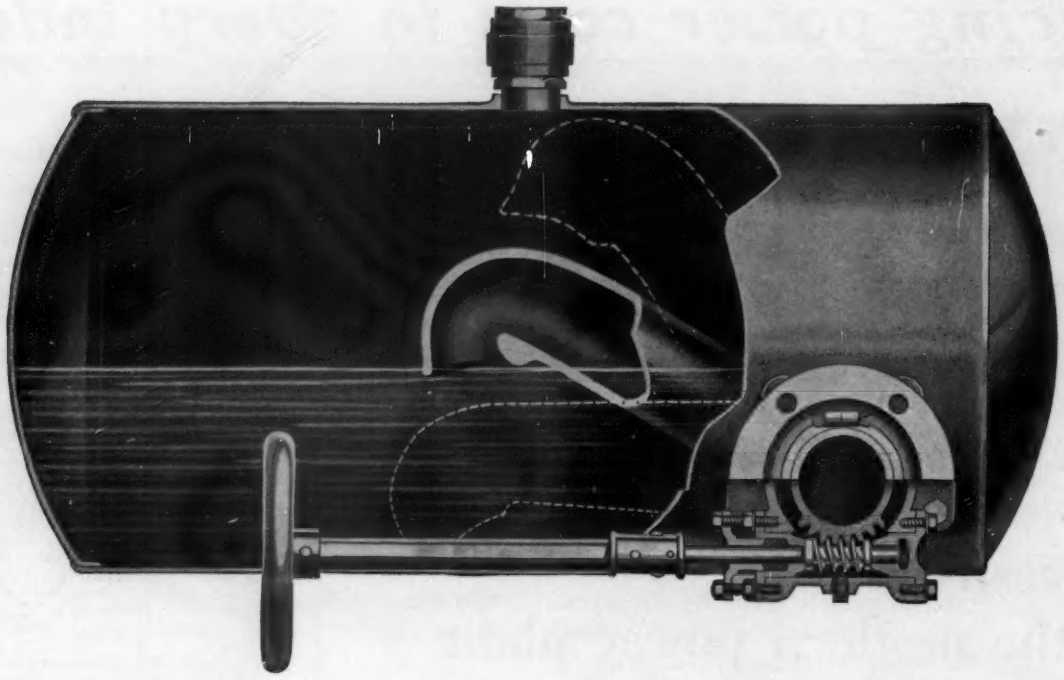
Are you posted on superheat? If not, send for the Foster Superheater Book, describing fully all the benefits of superheat and the special advantages of the patented Foster construction.

FOSTER
The SUPERHEATER
with the extended surface



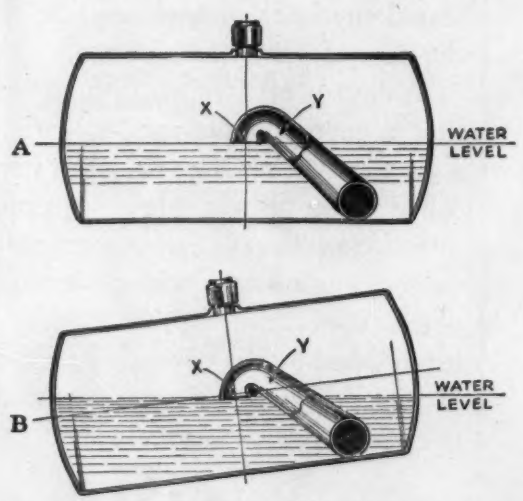
—another reason why Koehring Pavers Produce Dominant Strength Concrete

VITALLY important to the resultant strength and durability of concrete is the admittance of an accurate amount of water into the mixing drum at exactly the right instant. Long ago the Koehring Company recognized this fundamental requirement and set to work to devise an automatic water measuring system.

Today, the system is as nearly exact and accurate as human ingenuity has been able to design. A balanced three-way valve is automatically opened at a certain point, by the charging skip as it is raised, admitting the water into the mixing drum at exactly the right instant. The regulating hand wheel governs to a minute accuracy the amount of water which is to be used per batch.

All dribble is eliminated by the syphon-gravity principle which draws the water through a straight 3½ inch pipe into the mixing drum. Straight flow from the tank to drum secures a fast, clean discharge.

This is another pioneering development by Koehring engineers which with the Koehring batch meter, Koehring boom and bucket, and Koehring five action remixing principle produces standardized, dominant strength concrete of unvarying uniformity.



A and B illustrate clearly why changes of grade do not materially affect the accuracy of water measuring when using the Koehring system. X represents the volumetric center of the tank and Y the measuring arm.

"Concrete—Its Manufacture and Use" is a 210 page treatise on the uses of concrete, including 26 pages of tables of quantities of materials required in concrete paving work. To engineering students, faculty members and others interested we shall gladly send a copy on request.

KOEHRING COMPANY
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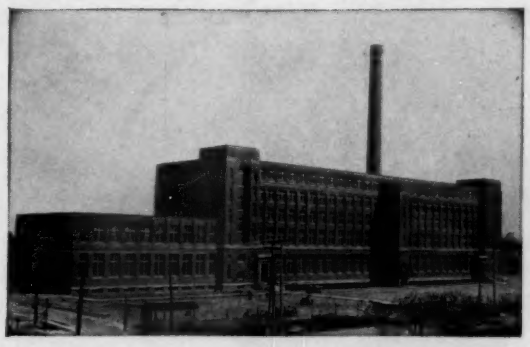
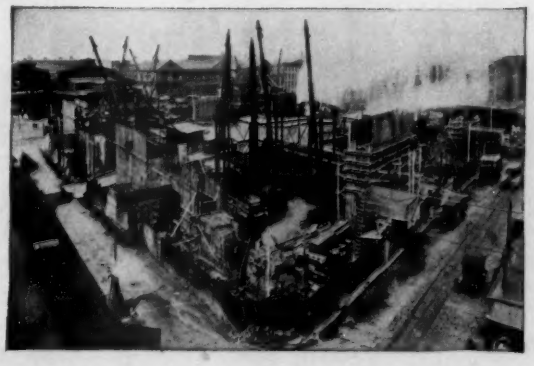
MANUFACTURERS OF PAVERS, MIXERS—GASOLINE SHOVELS, CRANES AND DRAGLINES

"From Turret to Foundation Stone"





Complete design and construction of all types of structures are included in the service offered by The Foundation Company. Efficient production in industry is dependent upon scientific design of plant;—and initial cost of plant is dependent upon economical, rapid and skillful construction.

Modern factory buildings must contain every facility to meet the demand for effective mechanical operation, and for consideration of the human operator. The mill built for Courtaulds, Limited, at Cornwall, Canada, s ia model of such factory construction.

The construction of the locomotive erecting shops of the Southern Railway at Atlanta, Georgia, is a notable example of complete service rendered by engineering contractor, working in full cooperation, in both design and construction, with the engineers of the railway company.

Often considerations of location determine a site where construction of the foundations is rendered unusually difficult. The New York Telephone Building, of which Marc Eidlitz & Son, Inc. were General Contractors, was placed where the Hudson River used to flow; yet modern methods permitted The Foundation Company to construct the substructure reaching to rock five stories below surface level.

These are but a few of the types of projects constructed by this organization.

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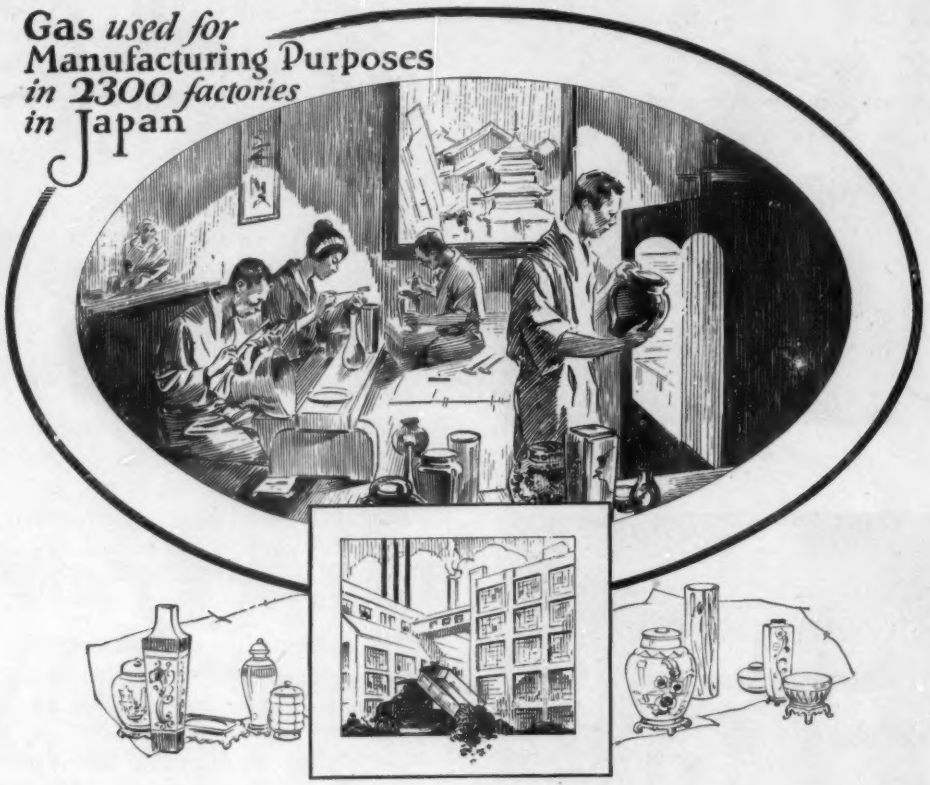
BUILDERS OF SUPERSTRUCTURES AS WELL AS SUBSTRUCTURES

There's Romance *in the* Story of Gas as a Practical Fuel



"East is East and West is West"~
Gas Fuel Meets the Needs of the Twain!

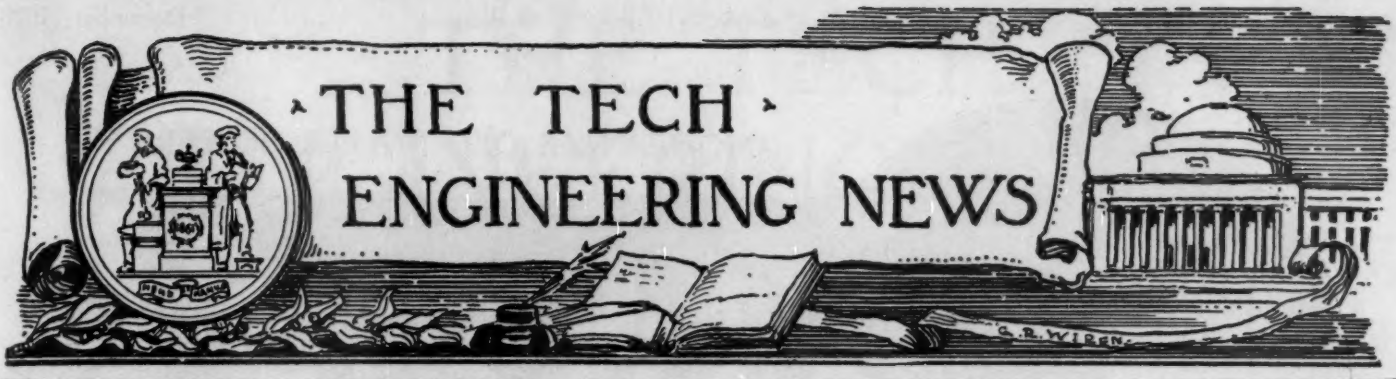
THE selfsame gas which makes the kettle sing merrily on the kitchen range is used alike by manufacturers all over the world. Gas is industrial fuel "stripped for action." By expert scientific means the raw material is rid of ashes, cinders, smoke, soot, dust and all other non-combustible ingredients at the gas plant. Gas Fuel is delivered through a pipe direct to point of actual use. It requires no storage room and almost no operating space. There is no stoking or waste disposal, and no capital is tied up in fuel supply.

Is it any wonder, then, that in Japan, as well as Boston, industries requiring heat for any purpose are making much use of this modern Super-Fuel, Gas?

"Fuel by Pipe Line"
Some of the many industrial uses of Gas Fuel provide heat for annealing copper wire, hardening steel, pasteurizing milk, pressing and steaming hats, baking, cooking, hardening lead, tempering oil, forming hosiery, etc.

ASK THE INDUSTRIAL DEPARTMENT OF BOSTON'S GAS COMPANY HOW GAS FUEL IS PROVING ITSELF PRACTICAL FOR YOUR BUSINESS

GAS Boston Consolidated Gas Company **FUEL**



Volume VII — Cambridge, Mass., December, 1926 — Number 6

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Entered as second class matter, June 1, 1920, at the Post Office at Boston, Mass., under the Act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized November 3, 1920.
Published monthly throughout the school year by the undergraduates of the Massachusetts Institute of Technology for the purpose of disseminating news of scientific and industrial interest and of promoting closer co-operation between Alumni and undergradutes.

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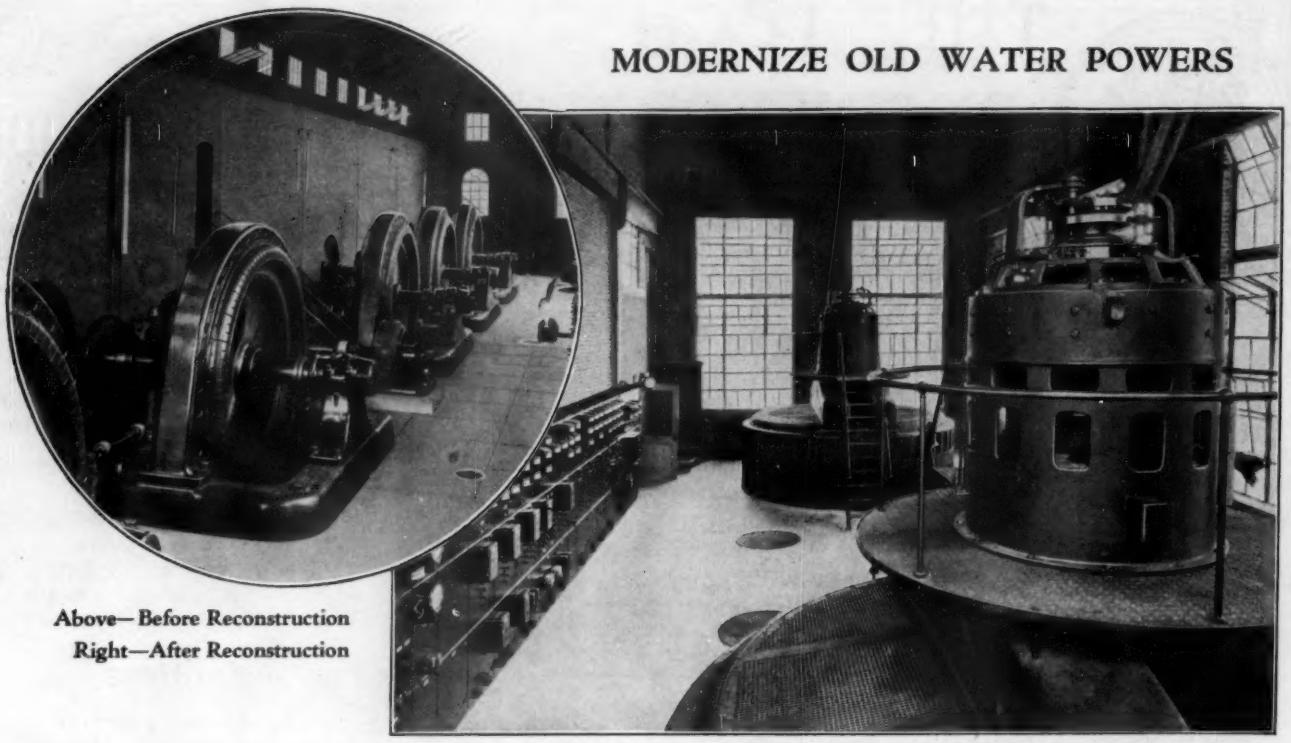
MODERNIZE OLD WATER POWERS



Above—Before Reconstruction
Right—After Reconstruction

GET maximum capacity and efficiency from your water power. By redevelopment our engineers improved the efficiency of the plant illustrated above by 25%. They are prepared to examine existing plants and to assist in their redevelopment.

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THE TECH
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THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME VII | DECEMBER, 1926 | NUMBER 6

Advanced Boiler Practice

A summary of the methods of obtaining highest efficiencies from boiler installations

By PROFESSOR E. F. MILLER, '86
Head of the Department of Mechanical Engineering, Massachusetts Institute of Technology

ONE hardly realizes when he sees the boiler equipment of a modern power station having boilers carrying pressures as high as 1200 and 1500 lbs. that forty years ago a boiler carrying 100 lbs. would have been considered as working under a very high pressure. Formerly boilers were rated on 15 sq. ft. of heating surface for what was then called a boiler horse power. As improvements were made which bettered the economy of boilers even with a higher rate of coal consumption per square foot of grate area, the heating surface was gradually reduced for rating horse power, dropping first to 12 and then to 10 and in all probability in the next few years boilers will be rated as low as 8 square feet of surface per horse power or perhaps even lower. If one looks at a drawing showing the setting of boilers he is surprised to find that forty years ago it was the custom to put the grate not more than 3 feet from the bottom of the boiler. As engineers learned more about combustion this distance was gradually increased until today in some of our stoker-fired plants there is a distance of 18 ft. or more between the grate and the heat-absorbing surface. Naturally with better and more complete combustion the thermal efficiency of boilers has increased; we now are getting 82 to 85% as against 68 to 70% of earlier years.

The introduction of the mechanical stoker and the reduction in the cost of the labor for firing was a very important step in lowering the cost of generation of steam, one man with modern stokers, powdered coal or oil, being able to handle 20,000 boiler horse power whereas with hand-firing 500 was the upper limit. The early mechanical stokers, while not giving any better thermal efficiency than could be obtained by hand-firing were nevertheless a good investment and the modern underfed stoker with forced draft in the ash-pit enabling boilers to be run at from 350 to 400% rating is a far better investment. In the modern boiler plants it is often the question whether coal should be burned on underfed stokers or burned as powdered fuel or whether oil either steam or mechanically atomized should be the source of the heat supply.

If a plant runs continuously throughout the year it makes little difference whether one burns coal on underfed stokers, powdered coal or fuel oil. When, however, a plant runs only 3000 hours a year the powdered coal or oil, will, without question, show a decided saving, there being no "banking" loss in the case of oil or powdered coal while for the underfed stoker the "banking" loss amounts to one-half a pound of coal per square foot of grate per hour of the banking period.

Some other items enter into the question of what should be used for a fuel, such items being outside of the relative cost.

As the price of fuel has gradually increased more attention has been given to increasing the economy of steam generating plants,—the first step was the introduction of economizers to recover heat from the flue gases. The loss of draft resulting from the use of an economizer in almost every case necessitated an induced draft fan which incidentally is a much more economical method of maintaining a flow through the gas passages of the boiler than the modern chimney, which depends for its operation on the difference in weight of the column of hot air in the chimney and the column of cold air outside of the chimney. In addition to the economizer many of the large plants have now installed between the economizer and chimney an air pre-heater which recovers still more heat from the flue gas transferring this heat to air which is forced through the pre-heater and thence into the ash-pit. Radiation from the outside walls of the boiler which formerly used to be from 8 to 10% of the heat of the fuel, is reduced down to 1% by the use of hollow furnace walls through which air on the way to the ash-pit is forced.

One of the great sources of trouble with modern boilers forced way beyond their rating has been the maintenance of the refractories in the boiler walls. This difficulty has been overcome in the larger boilers by the use of water-cooled surfaces such as the fin-tube and the Bailey wall, the tubes used in these water-cooled walls on account of the water circulation maintained through them protect the brick back of them and incidentally offer most excellent surface for the absorption of heat.

With the use of a stoker there is a certain amount of power required for operation, generally 2% of the entire output of steam. In the case of steam atomization of oil, again about 2% of the steam generated is used. Steam

(Continued on page 296)

Synthetic Methanol and Liquid Fuels from Coal

The latest authentic report on the efforts to develop a commercial process for this difficult conversion which is of such tremendous economic significance

By General Georges Patart
Inspector General of Explosives, of France

WITHIN a few weeks your library will probably be in possession of the complete Proceedings of the International Conference on Coal which contains the full text of my paper on the subject of "The Industrial Transformation of Coal into Organic Technical Products." Consequently, this lecture will deal with the further developments of special chemical and mechanical points of the new process: that is, the catalytic reaction between carbon monoxide and hydrogen.

I. *First experiments on the catalytic reaction between CO and H_2 at atmospheric pressure.*

This reaction was studied, twenty years ago, by the French scientist Sabatier, who can be called the father of catalysis—and he found, at that time, that the one reaction between these gases which takes place in presence of any catalytic agent was the formation of Methane (CH_4) according to the equation:

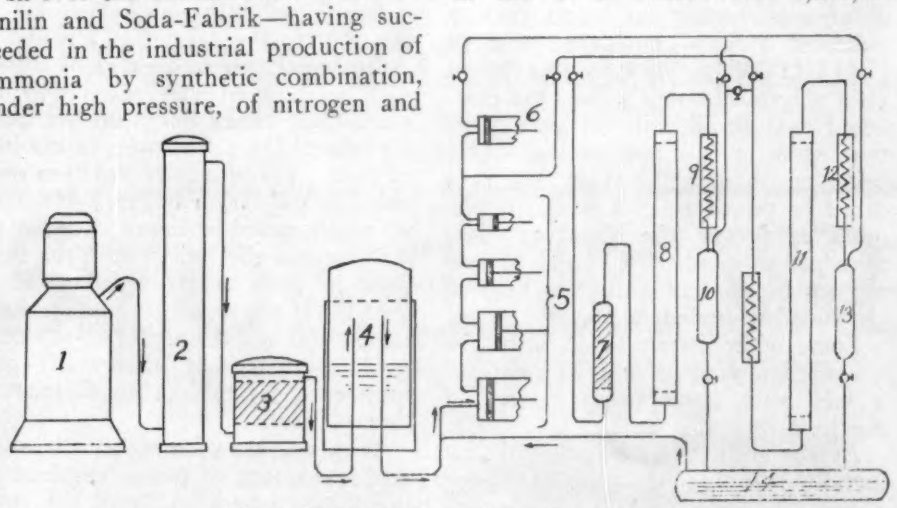
$$CO + 3H_2 = CH_4 + 2H_2O$$

His endeavor to obtain from these two gases an organic, oxygenated product (namely formaldehyde) was a failure. It is to be noticed that Sabatier worked exclusively at atmospheric pressure.

II. *First experiments on this catalytic reaction under high pressure.*

In 1913 the German firm—Badische Anilin and Soda-Fabrik—having succeeded in the industrial production of ammonia by synthetic combination, under high pressure, of nitrogen and hydrogen was quite naturally induced to try the same process of combining other gases with H_2; for example, CO. The results they obtained are given in German Patents of 1913 and in the U. S. Patent No. 1,201,850 filed February 11, 1914 by Alvin Mittasch and Christian Schneider.

During the week of November 15th, the first International Coal Conference was held at Pittsburgh, Pa. This conference was notable not only from the keen interest manifested, as indicated by the large attendance, over fifteen hundred delegates being registered, but also from the standpoint of the number and calibre of the delegates and speakers from Europe. One of the most prominent of these foreign delegates was General Georges Patart, Inspector General of Explosives, of France. General Patart is the French inventor of the process for making methyl alcohol from coal, one of the three important processes by which coal may be converted over to liquid fuel. The conversion of the solid fuels given us so abundantly by nature into liquid fuels so greatly demanded by our present day civilization is one of the most entrancing and important problems facing fuel engineers. The lecture explaining his process which was delivered by General Patart before students of the Gas and Fuel Engineering Course at M. I. T. at the invitation of Professor Haslam, is here published for the first time and most of the information contained therein is making its first appearance in American print.



SYNTHETIC METHANOL FLOW SHEET

I. Water gas producer. 2. Scrubber. 3. Sulphur Compound absorber. 4. Gas holder. 5. Four stages of compression. 6. Circulating pump. 7. Charcoal filter. 8. First catalyst tube. 9. First condenser. 10. First receiver. 11. Second catalyst tube. 12. Second condenser. 13. Second receiver. 14. Synthetic Alcohol tank.

III. *Methanol production by high pressure catalysis.*

In 1921, having myself resumed the study of the questions relating to the reaction of CO and H_2 under high pressure and in the presence of catalytic agents, I found that it was possible to obtain methanol as the chief and sole product of the reaction according to the equation:

$$CO + 2H_2 = CH_3OH$$

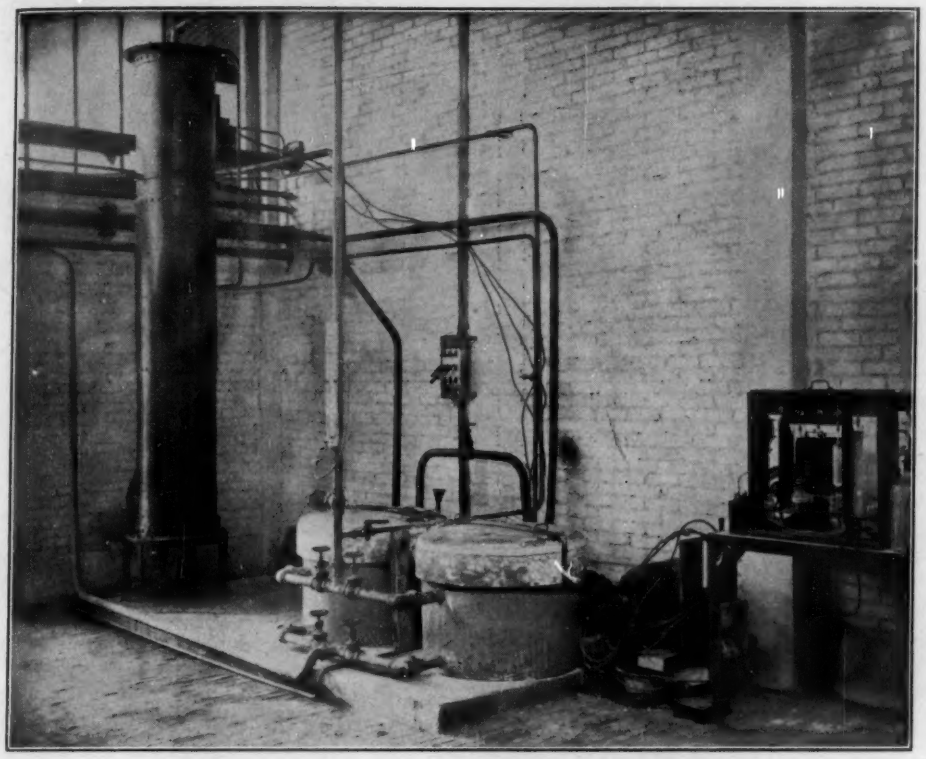
and that pretty nearly every catalyst known at that time as a hydrogenation or oxidation catalyst, was able, more or less, to promote this methanol formation. My French Patent was filed August 19th, 1921 and published July 1922. A short time after this publication (February 1923) Badische Anilin and Soda-Fabrik filed in Germany application for patent relating to methanol production by the same process.

In fact, my later experiments have shown that the reaction according to which CO and H_2 reacts to produce methanol is only one particular case of a much more general reaction which proceeds according to the two following equilibrium equations:

$$(1)\ n\,CO + 2n\,H_2 \rightleftharpoons (C_nH_{2n+1}OH) + (n-1)\,H_2O$$

$$(2)\ pCO + pH_2 \rightleftharpoons pCO_2 + pH_2O \quad (\text{if } n > 2, \text{ and } p = \frac{n+1}{2})$$

by which interaction every aliphatic alcohol can be obtained through the



SCRUBBER AND SULPHUR ABSORBERS

The tall cylinder on the left scrubs the gas coming from the producer. The two squat cylinders in the center foreground contain materials to remove from the gas all the sulphur compounds

use of ordinary water-gas according to the general equation:

(3)

$$\frac{3n}{2}\underbrace{(CO+H_2)}_{\text{water gas}}=C_nH_{2n+1}OH+\frac{n}{2}CO_2+(\frac{n}{2}-1)H_2O$$

IV. *Production of higher hydrocarbons at atmospheric pressure.*

Quite recently, Professor Franz Fischer, Director of the Kaiser Wilhelm Institute in Mülheim-Ruhr (Germany) made a remarkable discovery which came as a striking surprise to all scientists who, like myself, have been studying for years this interaction between CO and H_2. He found, at atmospheric pressure, that between certain limits of temperature and in the presence of some metallic catalyst (as cobalt or iron) the CO and H_2 can react to give hydrocarbons other than methane and that it was possible to absolutely avoid the formation of methane. Quite probably the reaction goes similarly to that giving the alcohols according to the two equations:

(4) $n\,CO + (2n + 1)\,H_2 = C_nH_{2n+2} + nH_2O$

(5) $pCO + pH_2 = pCO_2 + pH_2O$

by the interaction of which water gas can be transformed—directly and completely — into a mixture of saturated hydrocarbons of a composition entirely similar to that of American petroleum according to the equation:

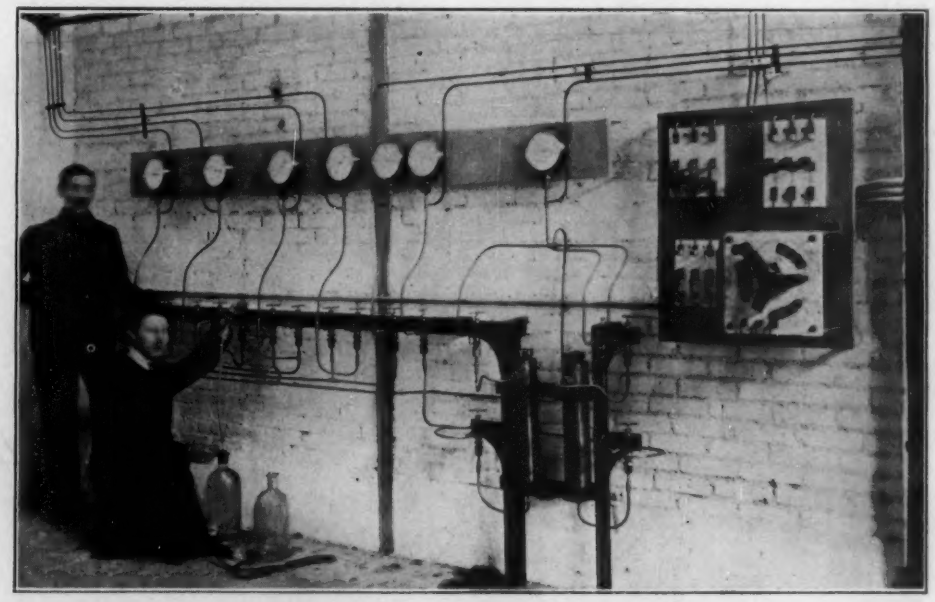
(6)

$$\frac{3n+1}{2}\underbrace{(CO+F_2)}_{\text{water gas}}=C_nH_{2n+2}+\frac{n+1}{2}CO_2+(\frac{n-1}{2})H_2O$$

As it is easy to see, the two processes for transforming the water gas, the first one—under high pressure—into alcohol, and the second one—under atmospheric pressure—into hydrocarbons, are giving approximately the same theoretical calorific yield. For example, in the formation of butanol this calorific yield would be 82.5 per cent and 83.3 per cent in the formation of butane, the difference (less than 1%) being due to the larger quantity of heat released in the formation of alcohol. But, calculated on the weight of the final product obtained from the same quantity of raw material, the yield is much higher for the alcohol formation than for the hydrocarbon formation. For example, the same volume of water gas would give 125 volumes of hexanol in place of 100 volumes of hexane. From another point of view, it must be remembered that the alcohols can be transformed easily into other products, for example into hydrocarbons by catalytic dehydration, or into aldehydes by catalytic dehydrogenation, but on the other hand, it is rather difficult to transform the hydrocarbons into their oxygenated derivatives. For these reasons, I think that the industrial importance of the transformation of water gas into alcohols by catalytic reaction under pressure is not lessened by Franz Fischer's discovery.

V. *Chemical realization of the synthesis of alcohol.*

This realization is affected by: (a) the composition of the mixture of the



CONTROL VALVE STATION

The numerous valves indicated on the flow sheet are all brought to this central point to facilitate effective and accurate operation of the process and taking of samples. Note the small size of the tubes adequate to carry large amounts of the highly compressed gas

reacting gases; (b) the composition and process of preparation of the catalyst; (c) the pressure, and (d) the temperature of the reacting gases.

(a) *Composition of the gas mixture.* As said before, the formation of a molecule of aliphatic alcohol (methanol or higher alcohol) requires the consumption of two molecules of hydrogen for every molecule of carbon monoxide and it has been found experimentally that the formation of methanol goes better as the composition of the gas mixture approaches two volumes of hydrogen for one volume of carbon monoxide. But it is nevertheless possible to use any mixture containing a higher proportion of carbon monoxide if there is added to the gas mixture a quantity of water sufficient to supply the deficiency of hydrogen, according to the equation:

$$CO + H_2O = CO_2 + H_2$$

For example the pure CO can be used directly for the production of methanol if water vapor is added to the carbon monoxide in the proportion of two volumes of water vapor for three volumes of carbon monoxide, as indicated by the equation:

$$3CO + 2H_2O = CH_3OH + 2CO_2$$

The presence of CO_2 in the gas mixture is not very troublesome for it is possible to avoid too high a proportion of this gas by its continuous elimination from the high pressure circuit itself by dissolving this CO_2 in water or in caustic soda. The other gases (as methane and nitrogen) which may be present are only troublesome because they lower the partial pressure of the reacting gases (CO and H_2) and since the reaction is more complete the higher the pressure the effect of the presence of the non-reacting gases (methane and nitrogen) is to decrease the production. The systematic evacuation, periodic or continuous, of these non-reacting gases is therefore necessary and I have given in my Pittsburgh paper a table showing the economical consequences of the proportion of non-reacting gases in the original gas mixture.

(b) *The catalytic agents.* As said before, there are many catalysts able to promote the formation of methanol, but the best one seems to be a mixture of oxide of zinc and oxides of chromium. The quantity of methanol obtained per hour with such a catalyst can reach 2 volumes per volume of catalyst at 250 atmospheres and 12 volumes at 900 atmospheres. This catalyst is not very sensitive to deteriorating influences. It keeps its special power a long time and can be regenerated easily after the impurities in the gases (such as sulphur) have penetrated the contact mass. The presence of some substance, for example, powdered, reduced nickel and iron, under definite conditions in the contact mass has a very noxious effect in producing methane, but the same substances lose their noxious influence if combined with other products in the form of salts or alloys. Alkaline metals, if existing in the contact mass, have another and very different influence; by a special mechanism, not yet quite well known, they promote the formation of higher alcohols with the elimination of excess oxygen in the form of water or carbonic acid, according to equation (3) above.

CATALYZING CHAMBERS

It is in these strong chambers that the gas is passed over the catalytic agent while the proper high temperature and pressure conditions are accurately measured and maintained. On the right are a condenser and a methanol collector bottle

(c) *Influence of pressure.* As in the ammonia synthesis, according to the general equilibrium laws, the formation of methanol and higher alcohols is promoted by increasing the pressure. The hourly production of a definite volume of catalyst is nearly proportional to the value of the pressure. As the consumption of mechanical power increases with the pressure, one must calculate, for every case, whether or not it is more expensive to increase the pressure or to increase the size of the catalyst chamber, the conducts and the circulating pump. In my opinion a pressure of 600 to 800 atmospheres is to be preferred. A high pressure is advantageous in reducing the cost of heating the catalyst as will be seen below.

(d) *Influence of the reaction's temperature.* The equilibrium proportion of methanol (or higher alcohols) produced at each passage of the gases over the catalysts, will be higher the lower the temperature. But, on the other hand, the speed of the reaction is so low at temperatures under 200°C that it is practically impossible to work at these lower temperatures. For an industrial production, it seems necessary to work at temperatures between 350°C and 400°C for the production of pure methanol, and between 450° and 500°C for the production of higher alcohols. With higher temperatures the formation of methane increases rapidly, involving a proportional loss in the utilization of the gases. To secure this temperature, a supply of external heat is generally necessary for balancing the heat carried off by the outgoing gases, conduction and radiation. When the quantity of circulating gases is the same, this external heat would decrease as the heat evolved by the exothermic reaction becomes greater.

VI. *Mechanical and practical realization of alcohol synthesis.*

An industrial plant for the realization of the reactions as above described must necessarily include the means of

(a) producing or extracting a gas mixture of a proper composition

(b) compressing the said mixture

(c) catalyzing the same

(d) condensing by cooling the alcohol vapors of the gas mixture

(e) separating the liquid from the uncombined gases

(f) returning these gases to the catalyst chamber

The whole of the necessary apparatus and their connections are shown on the sketch where it is supposed that there are two catalyst chambers work-

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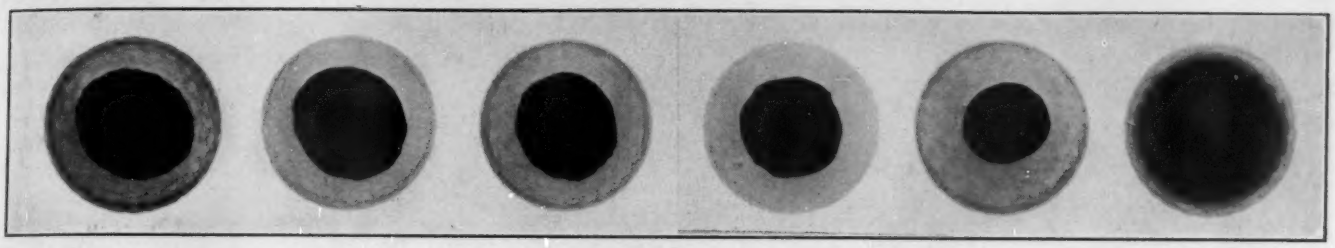


RADIOGRAPHS OF GOLF BALLS
Showing rubber cores and irregular centering

Radiography

This last article of the series is a short description of the uses of X-rays for the examination of the interior of opaque objects

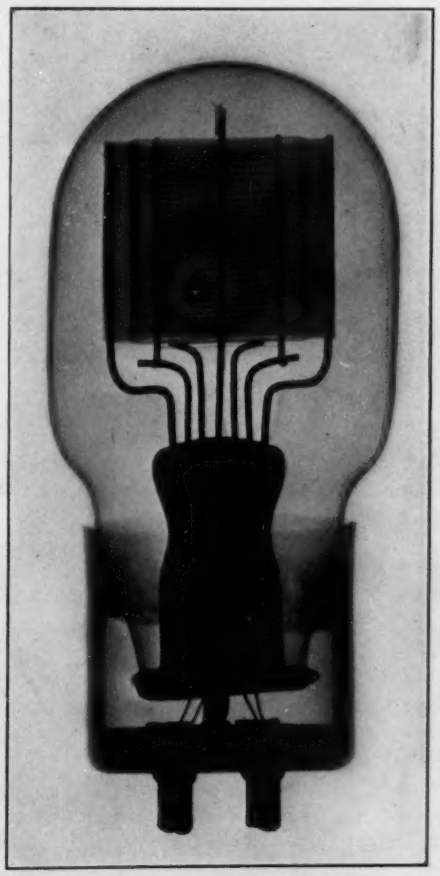
By JOHN T. NORTON, '18
Assistant Professor of Physics,
Massachusetts Institute of Technology

THE use of X-ray for the study of the gross interior structure of opaque materials is known as radiography. The very great penetrating power of X-radiation which has been one of its most striking properties since the moment of its discovery makes it possible to obtain a very complete picture of the interior of an object which is quite opaque to ordinary light. An X-ray picture is really a shadow picture of the object in which the different parts cast shadows which are distinguishable because they have absorbed different amounts of the X-rays. The absorption of a material depends upon its density and of course upon its thickness so that if the object is not homogeneous, the intensity of the X-ray passing through will not have a uniform distribution.

There are two ways of making these X-ray shadows visible. One employs a screen of some fluorescent material which glows with visible light when X-rays fall upon it. This is known as a fluoroscopic screen and the brightness of the glow is, under the proper conditions, proportional to the intensity of the X-rays. In this way the shadows may be observed directly. The other way of observing them is to use a photographic film which is sensitive to X-rays in the same way as it is to light. This film, when properly developed, gives a permanent image of the X-ray picture.

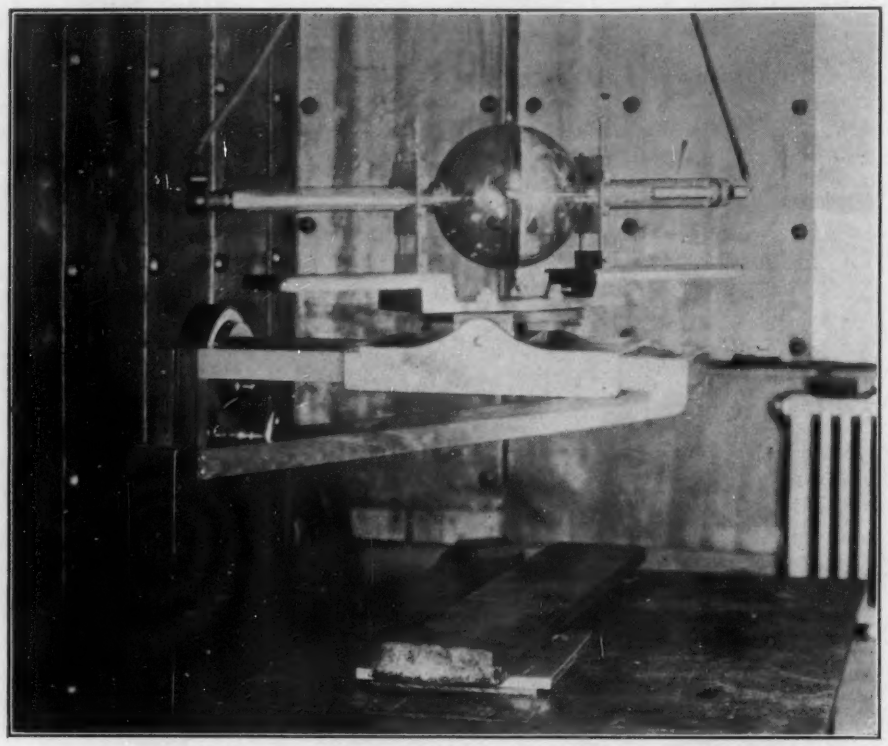
In its elements, the technique of taking a radiograph is very simple. The object is placed between an X-ray tube and the recording device and the proper exposure is made. Because the result is a shadow picture, it is essential to have the source as nearly a point as possible and to have the object close to the film or screen. Furthermore, the object must be properly oriented in order to show particular details desired.

The source of X-rays for radiographic work is usually some form of the Coolidge X-ray tube. Because of the various sizes and kinds of materials which are to be radiographed, it is necessary to use quite a wide range of voltages on the X-ray tube. For low-voltage work, the radiator type tube is the most satisfactory because of its high current carrying capacity and small focal spot. It may be used up to about 100,000 volts. Above this value, the so-called deep therapy type of tube is satisfactory and it has an upper limit of about 250,000 volts which is the maximum value in use at the present time. These tubes require a suitable high voltage generator and in the case of the deep therapy tube, it must supply uni-directional current. It is necessary to enclose the X-ray tube in a shield of lead or some other protective material. Often the whole room containing the apparatus is lead lined in which case the operator may be confident of complete protection.



RADIOGRAPH OF RADIO TUBE
Clearly showing details of construction

When recording X-ray pictures photographically, the question of the proper length of exposure is important. It depends upon the tube voltage, tube current, thickness and density of the object, arrangement of the film and several other conditions. As the object becomes more and more absorbent, the exposure becomes longer. If it becomes too long, the voltage must be raised to make the rays more penetrating. Since the tube current is a measure of the intensity of the radiation, one would expect that a constant product of time and current would give a constant blackening, other conditions being equal and this is found to be the case. Thus it is common to express exposures in milliampere-seconds or some similar unit. The film is placed in a flat box with a thin aluminum cover which is transparent to X-rays but opaque to light. The box, known as a cassette, also usually contains two fluorescent screens called intensifying screens which are pressed close against both sides of the double coated film and give off visible light which increases the image on the film. In this way, the exposures may be reduced some 15 or 20 times. At high voltages, thin metal foil is sometimes used as an in-



SET-UP FOR TAKING RADIOGRAPH OF CAST BRASS BILLET
The cassette containing the film is immediately under the Billet and the X-ray tube is above.

tensifying screen and while it is much less efficient as an intensifier, it helps cut off secondary radiation from the object. The proper exposures are only found by experience and are not necessarily the same for different machines. Some typical examples which have proven satisfactory in the author's laboratory are as follows. Aluminum, 1 inch thick, 5 milliampere-minutes at 90 kilovolts; steel 1 inch thick, 18 m.a.m. at 150 K. V.; Brass 1 inch thick, 22 m.a.m. at 225 K.V.; Steel 3 inches thick, 160 m.a.m. at 250 K.V. In all of these cases, the tube is 30 inches from the film and double intensifying screens are used.

The radiographic method of examination may be applied in a practical way to many different kinds of problems. In the medical field, these uses are quite well known and have proved to be of tremendous value. The difference in absorption between the bones and flesh of the body is sufficient to give good contrast, so that fractures, malformations, diseases of the bones and the like are quite evident. Diseases of the lungs, foreign objects in the stomach, gall stones, and many other conditions may be indicated and serve to illustrate the wide applications of X-ray methods in this particular field. No up-to-date hospital is without an X-ray department and a great many physicians and dentists have radiographic outfits in their offices. Until the last few years, all of the important developments in radiographic equipment and technique were made in response to demands from workers in the medical field and their trade forms the major portion of the business of X-ray apparatus manufacturers.

In the technical and industrial field, the conditions are somewhat different but in general the problems are much the same. Work of this nature may be divided into two general classes, one known as low voltage radiography which includes the study of objects that are sufficiently transparent to require X-ray tube voltages of less than 100,000, and high voltage radiography in which voltages from 100,000 to 250,000 volts are used.

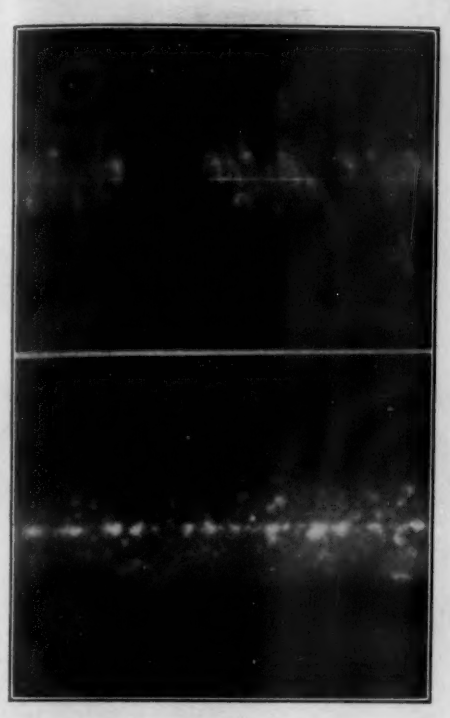
In the case of really transparent objects, the fluoroscopic screen may be used and it affords a rapid and inexpensive method of examination. Suitable materials to be examined in this way are wood, rubber, fibre, bakelite, insulating materials and objects of thin metal. Examples of such objects are very numerous. Built up wooden spars and ribs for airplanes may be readily inspected, sealed cases examined for smuggled goods, and automobile and airplane tires tested for details of construction. The fluoroscopic method has been developed for routine inspection in the testing of built-up mica sheet for insulating purposes by having the samples pass between tube and screen on a moving belt, the operator observing the screen through a mirror for reasons of protection.

The photographic record of the image of an object is much superior to the screen image and is used where good contrast and detail are desired. Under proper conditions, exceedingly fine detail can be obtained and in complicated electrical instruments the very small wires show plainly, even though embedded in several inches of insulating material. Recently, the radiography of golf balls has become important and in this case, the dense core of the ball shows plainly through the elastic winding. Since this core contains a considerable proportion of the mass of the ball, any lack of symmetry in its location will result in a very erratic behavior both in the air and on the green. Several dozen balls may be radiographed at once and it is not necessary to even break the seals on the boxes.

The great advantage which the radiographic method of examination possesses is the fact that the object is not changed in any way and at the same time a very intimate picture of its interior is obtained. In the case of many objects, inspection in the final form is difficult and often of no value because the defects are in the interior and opening up of the object is impossible without spoiling its appearance or usefulness. In this connection the method is of very great value because of the moral effect upon the workman, who realizes that it is possible to check up on his work in a very definite fashion even after it is completely finished.

When comparatively low voltages are used on the X-ray tube because of the transparency of the object, no particular precautions have to be taken to shield the film from secondary and scattered radiation. When, however, it becomes necessary to resort to higher voltages because of the increasing opacity of the material, shielding becomes a matter of prime importance and must be considered in all high voltage radiography. The materials to which high voltage radiography is most commonly applied are

RADIOGRAPH OF BRASS CASTING
Showing large shrinkage cavity



RADIOGRAPH OF WELDED JOINTS

Above: Shows weld in steel plate in which welding material has been piled up on top of joint, but there has been almost no fusion between the two plates.

Below: Shows defective weld in steel plate. The weld contains a large number of gas pockets.

the metals and they are usually in the form of castings or forgings. Castings are probably the most common metal articles and the ones in which defects most commonly occur so that the radiographic method of indicating the existence and magnitude of these defects is of utmost importance.

There are three general classes of defects which may and generally do occur in castings. The first of these is the blow-hole or gas pocket and is the inclusion of a quantity of gas in the metal as it solidifies. This gas may come from reaction of the elements of the melt, may be included mechanically, may be in the form of steam from moulding sand which is too wet, or it may be due to several causes. As a rule, gases are much more soluble in the molten metal than in the solid so that when solidification takes place, large quantities of gas are liberated and it appears as little bubbles all through the casting. The gas pockets are quite easy to distinguish on the radiograph because of their smooth and well rounded outline. Sometimes when the mould walls are more or less permeable, it is observed that a bubble of gas has moved through the metal while it is still in a mushy condition and left a well defined trail behind it.

The inclusion of sand or slag in the casting is quite common, but in general the quantity is not sufficient to be a very great source of trouble. The sand which is washed in by the molten metal usually comes from the ends of gates or risers which are improperly joined to the main body of the mould. These inclusions appear as irregular areas on the radiograph and usually have a more or less indefinite outline.

Shrinkage cracks and cavities form a very important class of casting defects and they are due to the fact that the metal shrinks as it solidifies and that the outside of the casting cools first so that there will be a cavity left in the central portion which is the last to freeze unless molten metal is fed in to keep this space filled up. If the risers are not properly designed, they will not feed the metal properly and the cavities result. Also in places where thick and thin parts join, these cavities frequently occur. If the casting is subjected to different rates of cooling in different parts, stresses are set up which may be enough to exceed the tensile strength of the metal and cause an actual crack to form. Shrinkage cavities appear on the X-ray film as definite pipe-like or fern-line areas and are quite characteristic. The fine cracks are more difficult to observe, but usually may be found if they do not happen to be exactly in a plane normal to the direction of the X-ray beam.

Because of the cost and the time required, it is not at present possible to examine casting in this way in a routine fashion. Each radiograph costs somewhere in the neighborhood of five dollars and quite a number would be necessary for the complete examination of a large casting so that routine examination would be out of the question. But there are several classes of work to which the method can be applied advantageously. Consider those castings whose proper performance is essential and which cannot possibly be allowed to fail in service. There are many such and parts of airplanes, racing cars, high pressure steam lines and oil stills are typical. In these cases where loss of property and life would be the result of failure, the cost of radiography is trivial as compared with the insurance which a positive method of investigation provides. And in many instances, this positive knowledge makes it possible to reduce the extremely large factors of safety which have placed on structures of this sort, resulting in a material saving in expense.

A particular application of this method was the radiographing of high pressure fittings and turbine casing of a large electric generating plant. Steam was used at 1200 pounds pressure and the damage and loss of money from tie up should this steam line fail can be easily imagined. Some of the cast steel fittings were rejected on the basis of the X-ray evidence and in one case, a forging substituted because a satisfactory casting could not be made after repeated trials. Many of these defective castings would have passed the regular inspection and any other really complete tests would have rendered the fittings unfit for use.

Another mode of application is to

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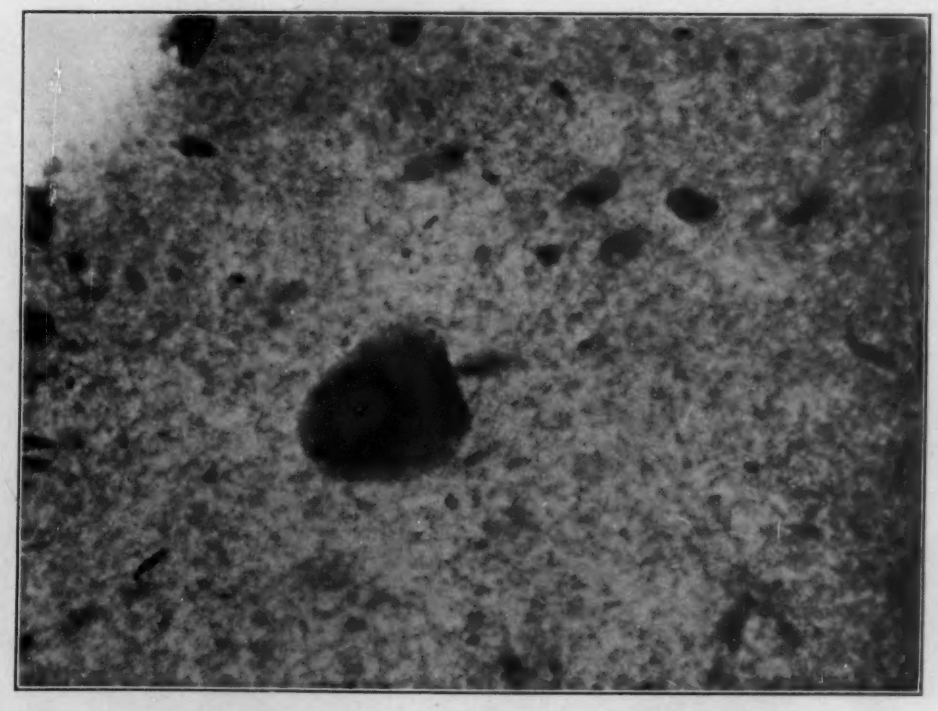

RADIOGRAPH OF INSULATING BRICK
Showing the great variation in particle size

Steam Power Stations

A brief review of the recent advances in the science of steam electric power production

By C. W. E. Clarke
Consulting Engineer, Dwight P. Robinson & Company, Incorporated

THE commercial production and distribution of electricity had its inception a little over forty years ago. The development from an idea to one of the greatest industries in the country not only from the viewpoint of financial size but from that of its importance in the every day life of the average man has taken place in this short span of years. Many other industries have grown along with it but probably none could have reached the present state of development without electricity as a source of power. In fact, most of the great developments of modern times have been made possible by electricity and to a great extent would have been impossible without it.

The term of this growth may be divided roughly into three parts. The first from about 1882 to about 1896 was a period of preliminary development. During this time the chief development was electrical, the generators or dynamos advanced from the old Edison "Jumbo" to the less bulky and less costly multipolar dynamo. The reciprocating steam engine had reached a relatively high state of excellence previous to 1882 and was ready as a fairly efficient prime mover. Little improvement of prime movers occurred during this period, though larger engines were built with considerable refinement in detail of design. Safer and more convenient electric switching equipment was worked out and distribution systems reached a state of fair reliability.

The second period from about 1896 to about 1908 was a period of marked improvement. The steam turbine was introduced and its value as a prime mover for electric generation was fully appreciated. Many relatively large power plants were constructed and all the component parts from handling the incoming fuel to switching and measuring the electrical energy were laid down in their fundamental forms. The only branch of the industry which failed to improve materially during this time was that relating to the combustion of fuel and generation of steam. Boilers and their furnaces underwent little improvement from the middle of the 19th century to the beginning of the 20th. Alternating current superseded direct current as the most satisfactory medium for generation and distribution except for very short distances, though some direct current systems such as that in the City of New York reached such proportions before the value of alternating current was recognized that a conversion to the latter form could not be economically justified.

The third period from about 1908 to the present time has been one of refinement. Very little change in the fundamental principles and equipment has taken place during this period. But, very marked improvement has occurred in the reduction of both first cost and operating costs. Along with a marked improvement in thermal economy a great reduction in labor requirement and maintenance costs has also been realized.

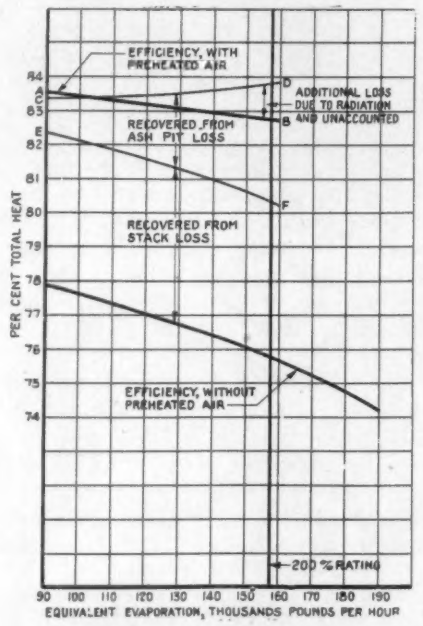

Fig. I. EFFECT OF PREHEATED AIR
A typical graph of the gain in boiler efficiency effected by preheating the air

Improvements in thermal economy has been due to the following factors:

Improvement and refinement of prime movers, generators and transformers, and increase in size of individual units.

Improvement, refinement and simplification of auxiliary apparatus such as condensers, pumps and fans.

Improvement in method of burning fuel, due to better furnace design, proper proportioning of the air-combustible ratio and increase in size of individual units.

Increase in steam pressure and temperature.

Introduction of the step extraction heating cycle wherein steam is bled from the main turbines at various points for heating the feed water.

Preheating air for combustion with the flue gases.

Recently steam reheating systems have been installed in several stations.

The improvement in labor costs has been due to the following factors:

A steady increase in the degree of automatic control.

Increase in size of individual units.

Replacement of manual operations with mechanical equipment.

Better design of power stations as a whole and in detail leading to increased reliability, elimination of duplication and overlapping duties and greater convenience of operation.

Improvement in maintenance costs has been due to:

Increased knowledge of the characteristics of materials of construction, of the service to which they are put and of their fitness for such service.

Increased size of individual units.

Though power stations in general cost more today in dollars per kilowatt of capacity than in 1910, if these costs are reduced to an equivalent purchasing power of the dollar the economic cost is less.

This reduction in economic cost has been largely due to increase in capacity of individual units resulting in a decrease in space requirement per kilowatt of capacity. The improvement in space economy is most marked in the replacement of engine driven with turbine driven equipment. The ground area required for large turbine driven generators is of the order of one-sixth that required for engine driven generators of the same capacity. The largest engine driven generators built were of about 7500 kw. capacity and the generators were so large as to represent about the practical limit in capacity. It was soon realized that the turbine driven unit had no such limitation. The high speed permitted a much smaller generator and the absence of elaborate valve gears and heavy reciprocating parts indicated

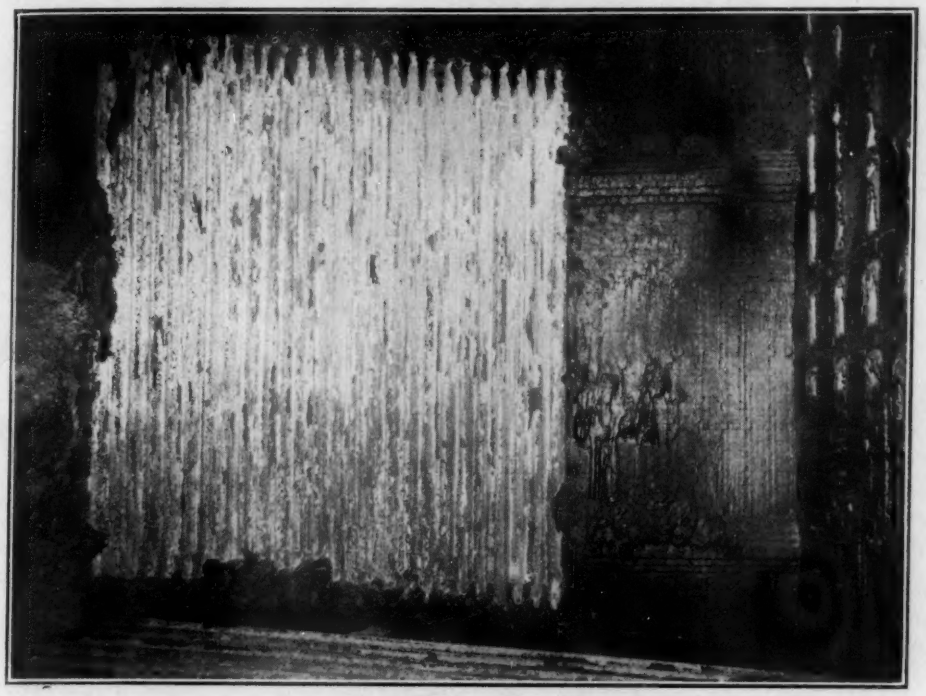

Fig. 2. WATER COOLED FIREBOX WALL
Slag accumulation on firebox walls of pulverized coal fired boiler is prevented and heat efficiently absorbed

that units of great capacity could be built. Today single units of 50,000 kw. capacity are in operation, and occupy not much more ground area than the 7500 kw. engine units of 1900.

In the boiler room there has also been a great increase in size of units. Previous to 1910, 6000 square feet of heating surface was thought to be about the limit in boiler size while today units of more than 30,000 square feet are in successful operation. The attendance required per piece of apparatus is not greatly affected by its size so that the cost of operation and maintenance of equipment is less per kilowatt of capacity than it was in 1910.

All of the foregoing factors have combined to bring about a great reduction in the economic cost of producing a kilowatt hour and starting it out on the distribution system.

The electrical equipment, transformers, switches, etc., have grown apace with the generating units though switches to handle the heavy currents produced by modern large generators present a problem that still occupies the designers. The modern large switch or circuit breaker is a very costly piece of apparatus and is only capable of breaking the circuit under full load a few times before it must be overhauled. The problem of handling the tremendous mechanical forces set up in large capacity electrical equipment under short circuit and broken circuit conditions is at present placing, at least temporarily, a limit on the magnitude of energy blocks that can be handled.

The great increase in the efficiency of combustion in boiler furnaces has been a chief contributor to the general improvement in power production economy. Stokers available about 1910 were inefficient and incapable of handling high ratings without heavy loss due to the discharge of partly burned fuel into the ash pit and the boiler furnaces were as a rule small in volume so that in the case of volatile fuels the gases were not in the furnace a sufficient time to permit complete combustion and much of the fuel passed out of the stack in the form of smoke. This condition was aggravated by the closeness of the boiler surfaces to the fuel bed which tended to keep the general furnace temperature down and inhibit combustion of the gases released from the fuel. This partial combustion resulted in dirty boiler surfaces and consequent high exit gas temperatures. At about this time engineers began to appreciate the value of increased furnace volumes and greater distance between fuel bed and boiler surface and a decided improvement in combustion efficiency immediately resulted. With increased furnace volumes, it was possible to burn greater quantities of fuel under a given boiler without excessive stack losses and a greater output per dollar of investment in boiler resulted. This condition forced the stoker designers to produce equipment that would burn larger quantities of fuel and accomplish complete volatilization before discharge into the ash pit. Fig. 3 shows a modern large boiler and setting for stoker firing. While in 1910 ratings of 200% were considered high and high efficiencies were rare, today boilers are operated at good efficiency up to 300% and in some cases at higher ratings.

With the better efficiencies came great increase in furnace temperature due to the lesser quantity of excess air used. Troubles from slag formation in the furnace which previously had been of little moment became serious and maintenance of the furnace walls was a very difficult problem. To cope with this difficulty the hollow air cooled wall was introduced. In this type of construction the furnace walls are hollow and arranged to permit the air for combustion to be drawn through them on its way to the furnace. With the introduction of preheated air, furnace temperatures reached a value such that the hollow wall was no longer satisfactory and experiments were tried with water cooled walls. Today the water cooled wall is generally used when the combustion air is preheated. There are several types on the market, all of them presenting either a metal or thin refractory surface to the furnace; the surface being cooled by passage of water from the boiler circulating system through tubes embedded in or forming part of the surface.

Within the past few years the burning of coal in pulverized form has come to the fore and today many of the large power stations proposed or in process of construction are to use this

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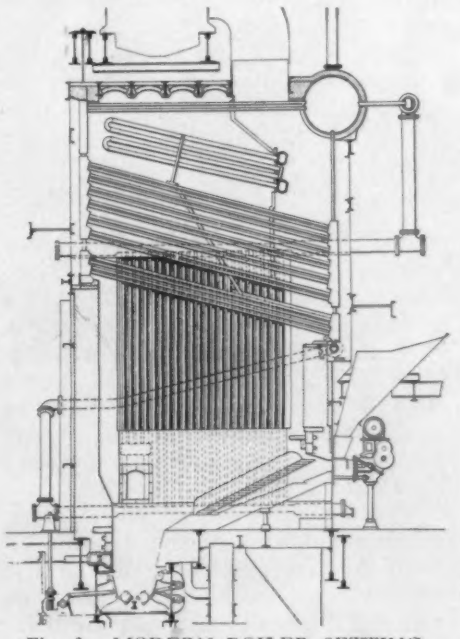


Fig. 3. MODERN BOILER SETTING
Note the great height of boiler tubes above stoker, also the water cooled walls

The Role of Chemistry in Power Generation

A survey of the part played by chemists and engineers in the more efficient generation of power

By J. T. Ward and
T. A. Mangelsdorf, '26
Assistant Professor and Research Assistant in the Fuel and Gas Engineering Course, Massachusetts Institute of Technology

THE generation of 95 percent of the power used in the United States is dependent on the release of energy through a chemical process—combustion. The tremendous importance of the chemical aspects of power development has until recently seldom been appreciated even by chemists and engineers. This growing realization has been forced by the serious depletion of the supplies of our choicest fuels and by the constantly increasing displacement of hand labor by power driven machinery. Substantial increases in the efficiency of power generation equipment have been made however and future developments have been forecast with the result that now not only technical men but the public as well clearly realize that the continued depletion of our fuel reserves necessitates further great advances in the efficiency of fuel utilization.

Industry the world over is engaged in a tremendous effort to decrease the cost and increase the productivity of its industrial processes. It is realized that the effectiveness of human labor can be greatly enhanced only when such labor directs the use of large quantities of power. In China where the power developed per capita is low, 85 workers out of every 100 are needed for the production of the necessaries of life leaving only 15 workers free to produce those articles of commerce which make for a higher standard of living. In the United States, with a high ratio of developed power per capita, almost the exact opposite is true. An inspection trip through any modern factory shows the multiplication ability of applied energy. Specific examples of the increasing use of power in industry are many. During a ten year interval in which industrial progress was interrupted by the World War the power consumed per worker in the production of glass increased 50%. In the manufacture of cement there was a 38% increase, leather 25%, automobiles 37%, silk goods 40%, men's clothing 47% and lime 133%. The actual rate of increase of energy consumption per capita is clearly shown in Figure I.

The upward trend of this curve is unmistakable evidence that we are far from the saturation point in the field of power generation. Constantly increasing quantities of power are being required which must be generated by the combustion of solid and liquid fuel the cost of which is increasing in price. This can be counteracted only by higher efficiencies which can be obtained only through intensive application of chemical as well as engineering principles.

For example the rapidly extending use of pulverized coal has introduced

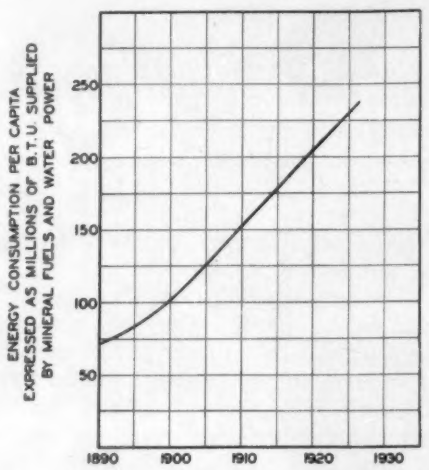


FIG. 1

Growth of energy consumption per capita

many chemical problems not encountered in the use of stoker fired equipment. Again, the use of very high steam pressures and temperatures has introduced new chemical problems, such as those relating to corrosion and hydrogen embrittlement. The number of chemists constantly employed in the solution of the chemical problems which are merely incident to the refining of petroleum, the source of automotive power, is surprisingly large. In short, not only is the essential liberation of energy in power production largely a chemical process but it involves a multitude of other chemical problems.

The extent to which our coal resources have been used up is perhaps often over emphasized. It is a fact, however, that the supplies of the best grades of steam coal have been so far depleted that the development of equipment for the use of lower grade fuels is being carried on actively. The only supplies of low priced fuel available to the industries of a large section of the country are the low rank coals of the middle west. The President's Conservation Board has recently reported that the end of our petroleum resources will be in sight within another ten years. The rapid growth in the amount of power generated in automotive equipment calls for a solution to the liquid fuel problem before the end of that period. The development of methods for the use of low grade coal in the production of substitutes for gasoline teems with chemical problems which must be solved in such a way that the future cost of automotive power will not increase inordinately.

These problems as well as many others have stimulated the imagination of chemists and engineers to the extent that a constantly increasing amount of research and development on radically new methods of power development is now being carried out.

Many of the proposals which are a result of this research work have been adopted and some are in the experimental stages, for example, the use of mercury and water in conjunction as boiler fluids, steam pressures as high as 1200 pounds per square inch, and the pre-carbonization of coal for recovery of hydrocarbons and gas previous to burning the resultant coke under boilers. The increased efficiency which may be derived from combining in a single plant the manufacture of city gas and the generation of electricity is being seriously discussed. New methods of domestic heating—oil and gas—are making rapid strides in displacing coal in some parts of the country. If the use of manufactured gas for house heating becomes an important part of the load of the gas plant its effect on the load factor may force the adoption of radically new methods of gasification of coal. The chemical aspects of all such developments as these are manifold.

The Liquid Fuel Problem

In discussing power and the fuel used to produce it we must also consider the fuel required for the production of heat or in manufacturing processes in which fuel is used otherwise than for power generation. It is necessary that our supplies of fuel be adequate for all purposes and one branch of industry often produces or processes fuel of enhanced value for another branch. This inter-relation-

ship becomes obvious when, for example, we consider that the increase in the number of automobiles threatens to disturb seriously an important raw material for the manufacture of city gas in that increased production of gasoline by the cracking process greatly reduces the available supply of oil used for enriching city gas. On the other hand the city gas plant or some of its processes, as we shall see later, may in the future secure the automobile from a dwindling supply of gasoline.

Calculations from available data show that our petroleum supply may last anywhere from ten to seventy-five years. The precise extent of our oil deposits is unknown. On the contrary it is possible to drill and survey a coal area to determine definitely the extent and character of the fuel and all seem to agree that we have quantities of bituminous and similar grades of coal sufficient to last for thousands of years. The indefiniteness of the petroleum supply forces us back on coal as the basic reserve of stored energy for all types of future power generation. However, a supply of gasoline for automobiles and motor trucks and fuel oil for ships must be assured. The liquid fuel problem, therefore, is one of converting our solid fuel, coal and lignite, over into gasoline and fuel oil—probably the greatest chemical task relating to the production of power. It is a problem that is being attacked by the chemist with that vigor and enthusiasm that he has applied to other problems in the field of fuel conversion, for example the manufacture of city gas from coal, the separation of petroleum into its more useful constituents and the cracking of the heavier hydrocarbons into gasoline.

Conversion of Coal to Oil

Approximately one fourth of the energy supplied by mineral fuels comes from petroleum. Whether or not one believes that the next decade will see the end of our natural oil resources it is quite certain that they will be almost exhausted long before our coal reserves are greatly reduced. Since one of the outstanding features of the present trend of power utilization is the great subdivision of power by means of small motors and automotive engines, it is certain that the requirements of these individual units must be supplied by means of liquid fuel. In Europe this situation is already at hand and as a result several methods for the conversion of coal into oil have been developed.

There are four main processes which may be considered in converting solid fuels, coal and shale, into liquid fuel oil. They are:

1. The low temperature carbonization of coal—resulting in a relatively small oil yield.
2. The conversion of coal into oil by the Bergius hydrogenation process —"Berginization."
3. The conversion of coal into water gas and the transformation of the gas into oil by the processes put forth by Fischer in Germany and Patart in France.
4. The distillation or rather cracking of our immense deposits of oil shale.

Low temperature distillation of coal is a possible source of oil inasmuch as coal that is being processed for other requirements may be specially treated to yield a supply of fuel oil. Approximately 12 percent of the original coal appears as oil and this oil has a value about equal to that of low grade crude oil. Although this process would not be a major factor in supplying liquid fuel it does offer very real possibilities to the Public Utility. Coal which is to be burned under the boiler may be carbonized at low temperatures so as to secure the oil, tar and gas. This gas on account of its high heating value is particularly valuable since it would replace the gas oil used for enrichment and therefore the equivalent amount of petroleum now used. Although not capable of furnishing the main supply of liquid fuel we may look on low temperature carbonization of coal—a chemical process—as a means whereby the supply of liquid fuels may be augmented.

The Bergius Process

From this process we may expect a much greater yield of oil than by any known method of low temperature carbonization. It consists in treating finely divided coal, suspended in an oil, with hydrogen under high pressure (2000-3000 pounds per square inch), at a temperature of 450°C. The product is mainly oil with some gas and residue. The hydrogen is essential since in normal bituminous coal the ratio of carbon to hydrogen is about 16 to 1 whereas in an oil it is about 8 to 1 and it follows that in order to convert coal into oil, hydrogen must be added. The character of the resulting oil depends upon the coal used and the conditions of conversion, but already coals used have yielded 15% of marketable gasoline, 20% of a heavier oil suitable for use in Diesel engines, 14% of heavy oil from which is obtained lubricating and fuel oil, and 20% of gas, which is similar to natural gas.

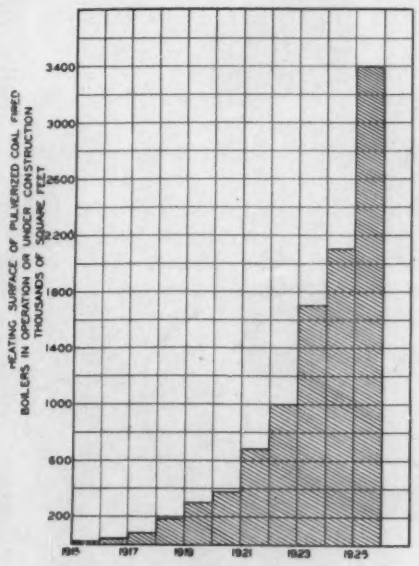


FIG. 2
Growth in the use of pulverized coal as boiler fuel

Berginization of coal is of particular interest from the chemical standpoint since it is a process for the direct conversion of solid fuel into oil. Its further development is certain to be rapid in Europe and it may be reckoned an important factor in the United States when our petroleum resources are depleted.

The Fischer and Patart Processes

Although working along different lines, Fischer in Germany and Patart in France, and others, are seeking the same ends, the production of coal from oil for generating power, particularly in the automotive type of engine. In this case, however, the coal is first gasified to produce water gas, mainly CO and H_2 which is then converted to alcohols. This conversion is accomplished by passing the purified gas over catalysts such as the oxides of cobalt, iron and chromium, at high pressures and temperatures. The exact type of product is dependent upon the conversion conditions and upon the catalyst. This type of process is now in successful commercial operation in Germany and its potentialities as a source of liquid fuels are great. Fischer has also reported a process of synthesizing hydrocarbons, more similar to our natural oils, by passing purified water gas over a catalyst at atmospheric pressure.

Increase in Thermal Efficiency of Central Power Stations

The increase in over-all thermal efficiency of the combined units making up central power station equipment has been remarkable in recent years. The average efficiency secured is probably below 15%. In 1913 the most efficient station reported that 1¼ pounds of coal were required for the

(Continued on page 300)

Departmental Notes

PROFESSOR WILLIAM EMERSON

ARCHITECTURE

The Department of Architecture has been busy for some years past in trying primarily to adjust its curriculum to the changing needs of the profession, and with that fairly underway to give attention to the more advanced work which shall ensure the highest grade of performance possible in the fifth year. To this end there has recently been published in the catalogue of graduate studies the requirement that any applicant for admission to our fifth year, leading to a Master's degree, shall have shown a competence in his architectural design above the passing grade or equivalent to a "Credit" grade in the Massachusetts Institute of Technology. This we are further supplementing by raising the percentage required for passing in this year from 60 to 65, but in order to compensate for these severe standards we are offering, with the consent of the Chairman of the Committee on Graduate Scholarships and Fellowships, an opportunity to one or more students who have completed their fifth year to continue the study of design without being required to pay tuition on condition that they complete a certain portion of the design requirements within the academic year, and of a grade equivalent to "Credit" or better.

These different steps have been accompanied by a change in the basis of selection for the holder of our annual Traveling Fellowship, which ensures to the winner a year of travel abroad. Hitherto this selection has been made as the result of a competition in design, open to all who had the necessary qualifications, but as very few of our former students, even though qualified to again compete for this honor, are able to return to do so after graduation we have decided to make the selection of the winner on the basis of his performance during his fifth year in design, believing that this is a safer guide for such a selection, and is not so severe a strain on the students at the end of their most critical year.

It would no doubt be of interest to Technology students in general to know that Professor Carlu, who is in charge of our advanced design, is engaged with Mr. H. J. Carlson, Architect, and member of the Corporation, in preparing plans for the future growth of Technology on the new land across Massachusetts Avenue.

Undergraduates would also be interested in knowing that our fourth and fifth year students who for years past have been entering conjunctive competitions with students of corresponding grades at the Harvard School of Architecture and the Boston Architectural Club, have maintained in recent problems the superiority in this field that marked their earlier work.

Recognizing the growing need for color in the architecture that is resulting from the newer types of construction in use at the present time, two new courses in the study of color in the junior and senior years have been recently introduced.

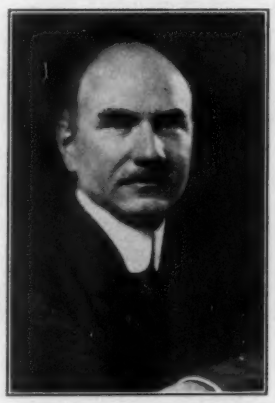
Following out the policy recommended by Dr. Stratton, and which this Department had already initiated some seven years ago, the appointed Corporation members of the Visiting Committee for the Department have been supplemented by a number of distinguished outside architects, some of whom are not Technology graduates, but all of whom are interested in the best development of educational methods in the architectural schools of today so that our curriculum may be subjected to a most searching analysis.

The cooperation of this Department has been asked in conjunction with the proposed new course in Building Construction and the suggested course in the Graphic Arts.

While the Department constantly receives individual gifts from those particularly interested in some phase of our work, two gifts of very unusual importance have recently come to us, one through the kindness of a former student, Richard H. Hunt, in the form of four of the original drawings by his father, Richard M. Hunt, being studies made by him for one of the pavilions of the Louvre in Paris. Considering the position that Mr. Hunt has held in the profession this is of particular significance. The other is the very generous recognition of our position in the teaching field by the widow of Bertram Grosvenor Goodhue in making this Department the guardian and trustee for the original drawings of her husband. No architect of our times has achieved such distinction in his profession as Bertram Goodhue, and his ability in every form of expression of an artistic nature is recognized by all who knew him, so that the Department is particularly to be congratulated. In this connection should also be mentioned a custom that was established two years ago by the graduating class of making a gift of money to the Department on its graduating day in order that some book or picture or other object of value to teaching might be added to our collection.

This, I think, completes the list of our present activities, and I trust shows how actively and loyally this Department is endeavoring to maintain the best Technology traditions.

WILLIAM EMERSON



PROFESSOR D. C. JACKSON

ELECTRICAL ENGINEERING DEPARTMENT

Through the courtesy of the Tech Engineering News a series of articles pertaining to the Electrical Engineering Department will be presented to the student body. The first article of this series may well be devoted to a general consideration of recent staff changes, department organization, and department educational activities.

The Electrical Engineering staff consists of fifty-four members for the present scholastic year and is one of the largest at the Institute. The distribution of rank is as follows: fifteen Professors, twenty-four Instructors, and sixteen Assistants. An unusual number of this staff are internationally known as practitioners, authors and educators.

Such a staff has a large turnover each year, particularly among the younger men who often come into our staff for one or two years for the purpose of securing the opportunities of

teaching experience and additional study. This year has seen an unusual change among those of faculty rank. Professor F. S. Dellenbaugh, Jr., resigned to take up administrative work with the United Fruit Company. Professor C. W. Ricker resigned in order to continue educational work as a Professor at the North Carolina State College. To balance these resignations of faculty rank, Assistant Professor Dahl was advanced to the grade of Associate Professor and Instructor Woodruff was promoted to the rank of Assistant Professor. Mr. A. R. Wood of the Philadelphia Electric Company was added to the staff in the capacity of Assistant Professor.

For the present year two important department committees have been appointed in order to more effectively carry on the department work. These committees are the Committee on Undergraduate Instruction and an enlarged Committee on Graduate Study. The first-named busies itself with a consideration of undergraduate curriculum and pedagogical methods; the second has essentially the same duties as the first but confines its activities to graduate courses and students. Such an arrangement has the distinct advantage of acquainting the entire staff with the problems at hand, it allows the discussion of ideas among the staff, and it gradually trains the younger staff to take up duties to which they may be promoted if they remain in educational work.

A consideration of the department's educational ideas and its application of them is naturally of interest to the student body. For example, some years ago it was conceived that a combination of supervised study with industrial practice would better prepare men planning to go into manufacturing work. This idea led to the formation of Course VI-A, a cooperative course given in conjunction with the General Electric Company. This is a five-year course leading to a Master's Degree and during the course the enrolled students spend their time alternately at the Institute and at the General Electric Company. Such a course justified itself and now similar cooperative courses are given in conjunction with Stone and Webster, The Bell (Telephone) System, the Edison Electric Illuminating Company of Boston, and the Boston Elevated Railway. Thus cooperative courses in the Electrical Engineering Department now cover manufacturing, operation, and public utilities. Graduate work is also given to a limited list of the younger engineers employed by the General Electric Company at its Lynn Works.

Last year the department took a decidedly important step in undergraduate teaching methods. This is an endeavor to recognize more fully that mental growth, like physical, is different for different individuals in undergraduate as well as in graduate work. Recognition of variation in mental growth necessitates that the methods of instruction be adapted to the individual. The type of instruction which holds very close to the textbook for class room work and includes much repetition and drill involving fundamentals is admirably suited to the slowly growing mind. However, instruction of this type may be detrimental when applied to a mind which nature has endowed with unusual retentiveness and insight. The ideal recognition of each individual would be individual instruction of a type suited to the mental equipment of each student. To secure this effect as largely as practicable, the department has resorted to mental grouping in the undergraduate classes as a means of individual recognition. That is, the sophomore, junior, and senior students, by an analysis of their past records are divided into four groups; those of markedly exceptional activity of mind, those somewhat above the average, the average, and those below the average. The class room instruction for the last three groups is adjusted to the class requirements. The instruction for the first group, now called an Honor Group, is entirely individual, in that class room attendance is optional in all subjects but conferences are provided for. At the end of the term all groups take the same final examination and are thus held responsible for the same minimum amount of work as under the previous system of instruction. The new method allows the more active of minds to take their subjects in a more advanced perspective, and unhandicapped by a rigid class schedule they have available much more time to devote to professional or cultural reading. Experience shows that men of really exceptional capacity profit by the opportunities afforded to the Honor Group.

Perhaps one might think that a particular stamp associates itself with the various groups. This is not the case because there are no rigid barriers between groups. Marked performance on the part of any student entitles him to advance from his group to the one ahead and should a student feel lost in one group he may be shifted into another group until he finds a type of instruction best fitted to his mental make-up. Further it is found that the students are men enough to squarely face the existence of variation in mental growth and thus they may look upon mental grouping as a sincere effort on the part of the department to help them get the most out of what is offered. The department in working out its educational ideas is much indebted to the cooperation of other departments and its own students.

Other articles to appear in succeeding issues will deal with staff and student activities in the various divisions of the department. Of particular interest will be some statement of the graduate work of the department and the accomplishments of the Research Division such as the development of an automatic machine for making breakdown tests on insulation, electrical integrating machines, and artificial transmission lines and cables.

E. G. Bangratz

PROFESSOR E. P. WARNER

AERONAUTICAL ENGINEERING

Although aeronautical subjects have been taught at Technology for a number of years, an undergraduate course in this subject was established only last spring. Due to the relatively small size of the aeronautical industry and the consequent limited demand for personnel, a complete undergraduate course in Aeronautics was not considered necessary previous to that time. The recent rapid growth of the industry together with the indications of continued expansion, led to the establishment of Course XVI which went into operation at the beginning of this academic year. The registration in this course has been very g r a t i f y i n g, approximately twenty-one second year men having elected this branch. Beyond the second year the registration is much smaller due to the difficulties involved in transferring from other courses and making up the necessary subjects. The registration in junior year is seven, and in senior year two. A number of seniors, however, are

(Continued on page 284)

The Pictorial Section

An illustrated description of some of the equipment used in the production of industrial power

OUR modern civilization may safely be said to be measured by the efficiency of the production of industrial power. In our last issue, we discussed some of the problems involved in the generation and distribution of hydroelectric power. We showed the tremendous possibilities of this form of power but it has very severe limitations. These arrive from the fact that we use more power in this country than we have available in the form of waterpower.

Furthermore, the water power we have is not always so situated as to be of maximum efficiency to a manufacturing establishment.

For these reasons, waterpower supplies but a small fraction of the total power used in this country. The remainder is furnished by burning some sort of fuel. The principal types of power generation by fuel are the steam plant in its various forms and the oil engine. In this issue we discuss factors affecting the design and operation of steam and Diesel installations.

Formerly the average steam plant had an efficiency of less than 10%. This has raised a great deal within the past 25 years. In the various power articles featured in this issue, the progress is traced through to the modern central station using steam at a very high pressure and temperature with a surprising over-all efficiency.

In this section we are showing some of the equipment found in the modern power plant with a brief description of its uses and method of operation.

Fig. 1 shows the crankcase and crankshaft of a large 3000 H.P. Diesel engine. The picture gives one a good idea of the size of a Diesel engine. The crankshaft is built up and very accurately aligned in its bearings to minimize wear.

Fig. 4 is an external view of a 720 H.P. Diesel engine. This engine has become quite popular especially for ship propulsion and offers great possibilities. It runs on crude oil with a very high efficiency. The engine is comparatively simple as it does not require any ignition or carburetion devices.

Formerly when boilers were built in smaller units one man could fire a boiler with a fair amount of success. Now, however, with our present large boilers it would be out of the question to fire by hand.

Various means have been devised to fire the large boilers of today. The three main methods have been by automatic stoker using ordinary coal, by oil sprayed through jets and burned, and by pulverized coal atomized into the boiler as a cloud of coal dust.

Fig. 2 gives one a good idea of the boiler side of an automatic stoker. This stoker feeds the coal into the furnace in the right amount to secure good combustion and also provides for the removal of the ashes. The stoker shown is of the multiple retort underfed type. It consists of a stationary tuyere structure, between the sections of which are set ram boxes containing cylindrical feeding rams and a series of overlapping flat distributing rams forming the bottom of each retort. The individual adjustment of each ram allows the proper amount of fuel to be fed to each part of the retort satisfactorily meeting the combustion requirements of different grades of coal. A rotary ash discharger is shown to the left in this view.

Its function is to cool, crush and discharge the ash as fast as is necessary to operate the furnace efficiently.

Fig. 8 is an external view of another stoker showing the method of conducting the coal from overhead bins to the stoker. This eliminates a lot of manual labor which is always costly and inefficient. Fig. 12 conveys an excellent idea of the set up of a complete boiler with its furnace. This boiler is of the water tube type. The grate is placed at a considerable distance below the tubes giving a higher thermal efficiency than would otherwise be obtained.

This view also shows the baffle walls which lead the flames around to the tubes. The grate in this furnace is designed to have the coal fed down the center of the furnace and as the ash forms, it rolls down the sloping sides into the pit. This gives a good self-cleaning action to the furnace.

Fig. 9 is a view of the construction of a water tube boiler equipped with superheater. The superheater is clearly shown on the left bank of tubes. This boiler is a fair example of conventional boiler practice. Most of our industrial boilers now use superheated steam which gives excellent results with modern turbines.

Formerly power was usually produced by reciprocating steam engines. These engines, for the most part, gave low operating efficiencies and were most uneconomical from the standpoint of space economy. The turbine has largely replaced the steam engine for most purposes although certain forms of steam engines, such as the unaflow do give an excellent efficiency.

Fig. 7 shows an axial section of a De Laval velocity stage turbine designed for the use of high pressure superheated steam. These turbines are wonderful pieces of mechanism and necessitate the greatest care in construction in order to secure satisfactory operation. The periphery of the runner travels with a velocity approximately one-quarter that of the expanded steam. Any inaccuracies in balancing of the runner would introduce severe forces at this speed. This turbine has the steam inlet nozzle, governor, valve bodies and steam chest formed in the upper part of the casing cover where they are far away from, and do not transmit heat to, the bearings and oil wells.

As these turbines rotate at so high a speed, provision must be made to reduce this speed and also to allow for a higher starting torque than could be obtained ordinarily. This reduction is accomplished by gears. The reduction gear for a 22,500 H.P. installation is shown in Fig. 6. This reduction gear is of the two pinion double helical type.

Figs. 10 and 13 show views of other popular turbines. Fig. 13 shows the Terry type Z2 turbine in which a special type of wheel is employed. The view clearly shows the peculiar shape and position of the blading.

Most turbines operate best when exhausting into a vacuum. Fig. 18 shows a condenser which will condense the exhaust steam providing a high vacuum on the runner.

Fig. 11 shows a centrifugal pump which is a common unit around a central station. Fig. 5 shows a large blower for use in ventilating an engine room and similar blowers are used to ventilate the interior of large alternators.

Fig. 3 shows the Carrier air conditioning equipment which can be treated under power plant equipment. This machine may be used as either a humidifier or dehumidifier. It provides air to a building containing any degree of moisture and at a given temperature. It is of especial value around spinning mills and in other plants where the condition of the air is an important factor.

ADAM K. STRICKER, JR.

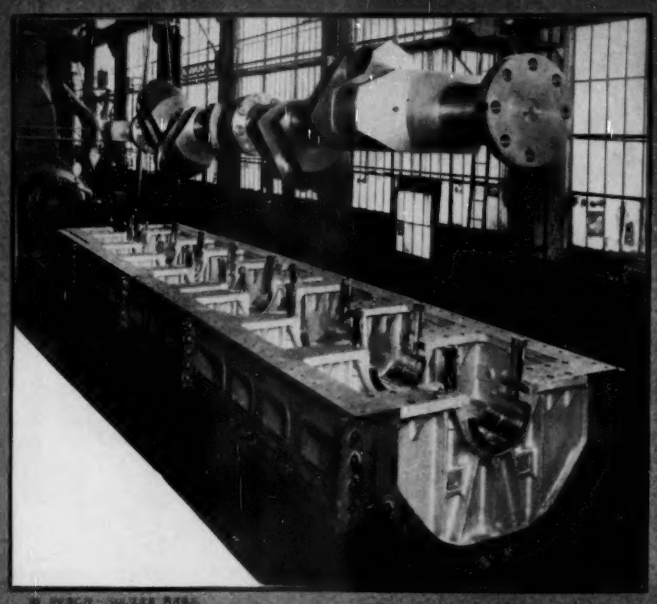


FIG. 1
CRANKSHAFT OF DIESEL ENGINE

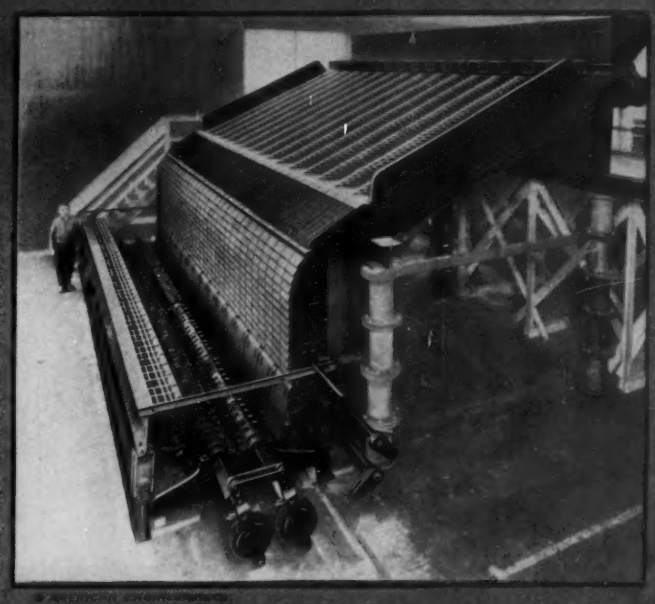


FIG 2
AUTOMATIC STOKER

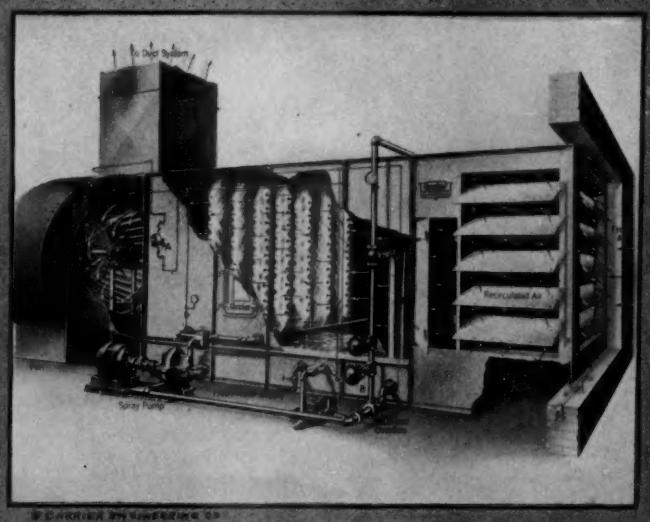


FIG. 3
AIR HUMIDIFIER

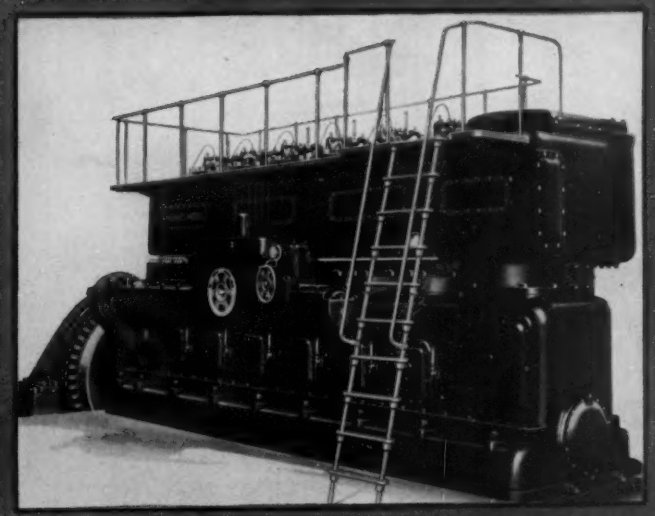


FIG. 4
720 H.P. DIESEL ENGINE

FIG. 5
[illegible] VENTILATING BLOWER

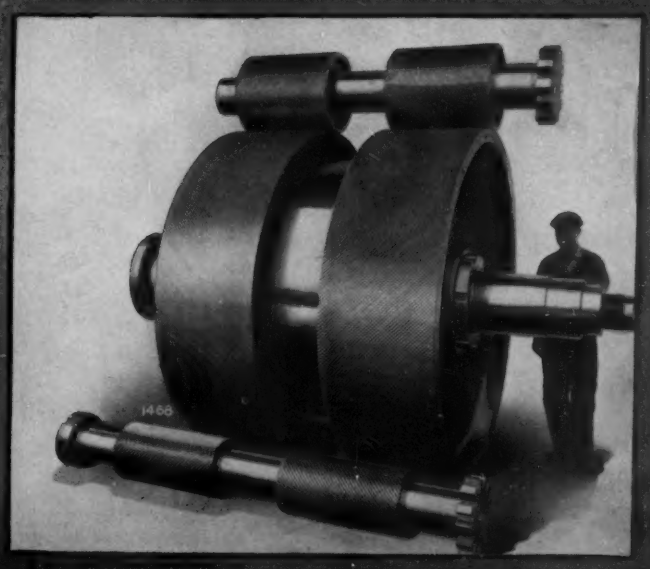


FIG. 6
TURBINE REDUCTION GEAR

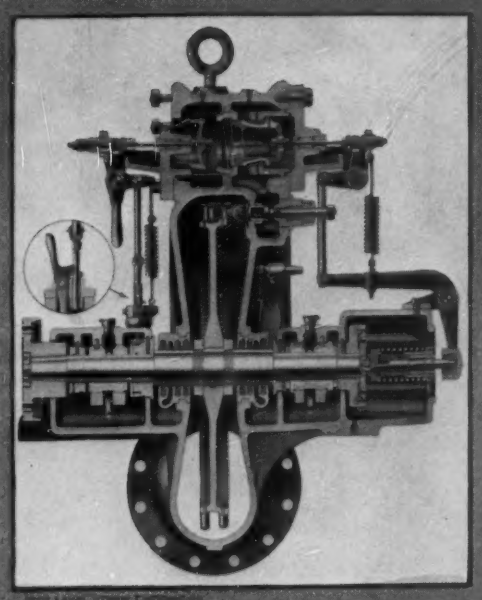


FIG 7
VELOCITY STAGE TURBINE

FIG. 8
BOILER WITH STOKER

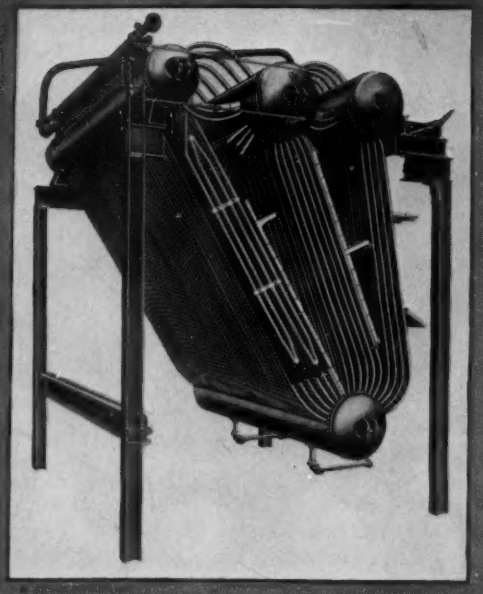


FIG. 9
BOILER WITH SUPERHEATER

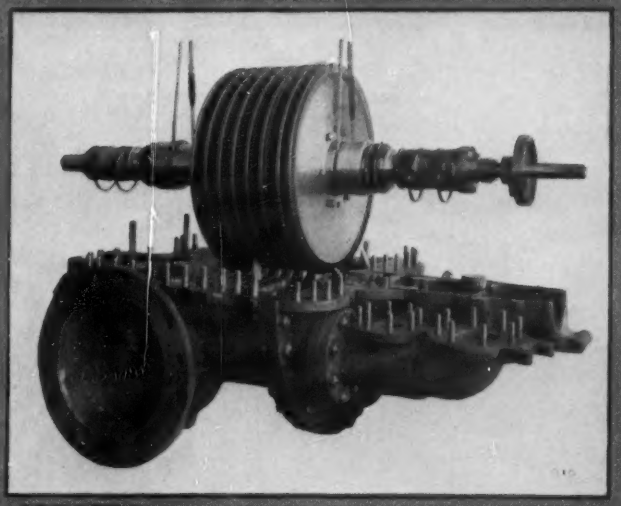


FIG. 10
TERRY TURBINE

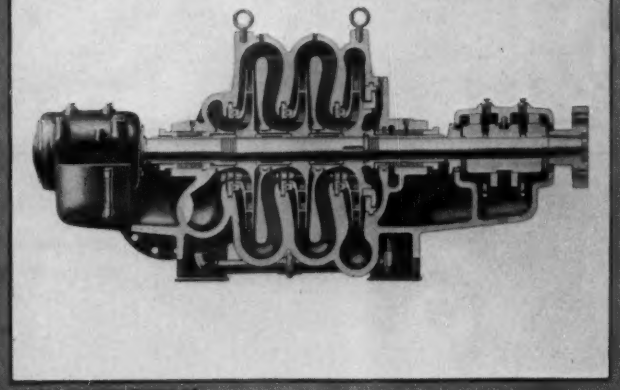


FIG. 11
CENTRIFUGAL PUMP

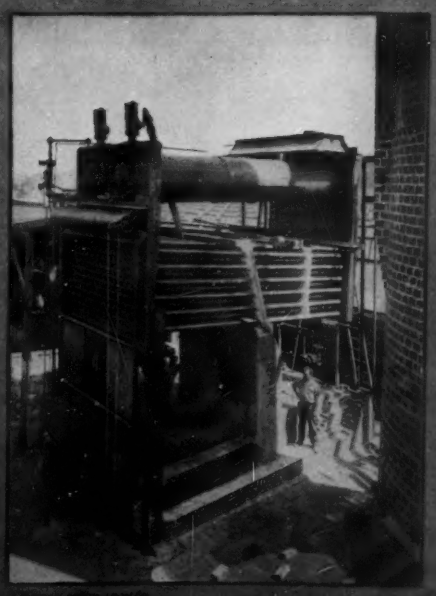


FIG. 12
BOILER WITH MOUNTING

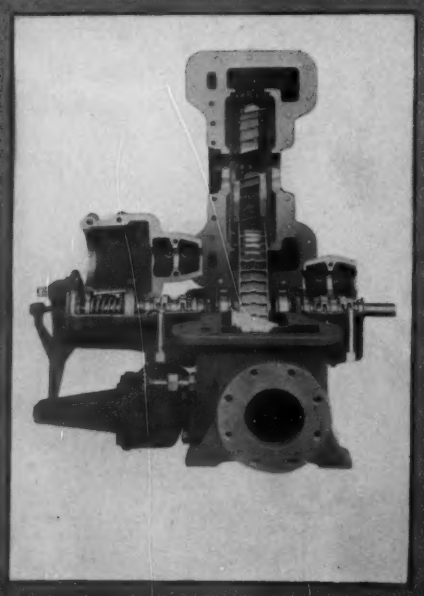


FIG. 13
SECTION OF TERRY Z_2 TURBINE

FIG. 14
CONDENSER

Editorials

DIFFERENT OPINIONS

While the students here are going through the routine of studying and preparing for tests, engineering students in other schools are thinking about transferring here. Subjects and requirements in Tech's catalogs and stories of overwork are considered simultaneously. After much deliberation, the fellows come to the conclusion that they are not endowed with sufficient brains to make the change and so peacefully settle down to make their present schools their Alma Mater.

In almost all schools and especially so in the large mid-western state universities, the prevalent idea is that assignments at Tech are extremely long. As a result, many very capable fellows who would like to transfer feel that they could not survive.

A few brief statements in regard to teaching and studying at Tech compared with methods used in mid-western schools may explain criticisms so often made.

Here at the Institute daily reading and home problem assignments are given. The assignments are thoroughly covered outside and the class period is used to explain any difficulty which may have been encountered. After all the questions have been answered, the instructor supplements the reading assignment with incidents from his personal experience or he may work problems not covered in text. No attempt is made to teach the subject in class. Tests cover text-book reading and as is generally known, determines the student's knowledge of the subject quite effectively.

In the mid-western schools, the instructors do the teaching and the students do the absorbing. Although reading assignments are longer than here and more problems are assigned, the students do less homework because by careful attention to the lectures all important points are explained and little outside study is required. The lectures cover the preceding assignment and problems pertaining to those topics are assigned after the lecture. The tests cover only those topics which have been discussed and emphasized in class.

When exaggerated stories about Tech get to the various campuses, the fellows feel that all the Institute men are brown baggers who, when they graduate, are physical wrecks. When the westerners learn that all studying must be done outside of classes and that lectures only supplement the course, one can readily understand the foundation of their beliefs. The paths of least resistance are generally followed. The fellows in the large co-educational institution feel that after a day of concentrated attention to lectures they can well afford to spend the evening at a sorority house or at a dance. These entertainments find their line on each page of the daily diary. The idea of going to classes and then studying the subject on the outside does not appeal to the student in the marriage bureau colleges of the mid-west.

Tutoring here at the Institute to organize the scattered material and to point out important relationship is very beneficial and quite frequently done. In mid-western colleges this outlining is done every day by the instructor so very little outside tutoring is done except in mathematics where cramming the last week before the finals is quite often relied upon.

Studying scientific subjects in school is just a training for the men who will make engineering or business their professions. Students who have been accustomed to study subjects alone can organize data into workable material. They can gather information in a shop and attack the problems intelligently. The fellow who had everything taught him will be lost without the aid of his instructor.

Which students will be more successful; those who studied or those who were taught? Although Tech's system requires more work, the rewards ought to be greater than where less individual thinking is required. So we realize the truth of the saying, "One gets out of a subject what one puts in."

THE COVER

The original of the pencil sketch reproduced on the cover of this month's TECH ENGINEERING NEWS is found in a collection of drawings "Boston—Its Byways and Highways" by John Albert Seaford. It is an unusual view of the Roll Lift Bridge at Fort Point Channel in Boston. As the artist himself phrases it, "When raised for the passing vessels, the huge affair presents a striking spectacle rearing above a medley of smoking engines and network of passing trains."

THE Y. C. LAB

For a little more than a year, now, there has been developing one of the finest projects in human engineering it has ever been our privilege to witness. We are especially interested because it is developing youths who give promise of becoming splendid engineers.

We refer to the Y. C. Lab, "The National Society for Ingenious Boys," conducted by the Youth's Companion. It is succeeding admirably, through the pages of this weekly publication, in reaching boys all over the country —even in Alaska—who early in life, that is before the age of nineteen, have shown not only the desire to build things, but further, the initiative as well as the ability to go ahead and do it.

This Lab is a new thing and is really accomplishing tangible results. Boys send in with their application for membership in the Lab Association an account of some project of a mechanical, electrical, engineering or constructional nature which they have under way or have completed. There are no fees or dues. Elections to the Society are made dependent upon the "ingenuity, skill and diligence" and the ability to write a clear report of the project, shown by the applicant. Where the first three qualities are evident special attention is given to developing this last named ability.

Elected to the Society a boy has free access to the most expert advice obtainable in answer to his questions of a related nature which are written and sent to the headquarters of the Society. Several of the members of our own Faculty are now acting as councillors to the Society, answering the boys' questions, guiding them to sources of information, encouraging them in their work, testing and criticising their products.

The Society maintains a laboratory of its own in which the work is done by boys who are members. Here new ideas for projects are both originated and carried through so that when presented to the rest of the membership they may rest assured that the plan is feasible because it has really been accomplished by boys of similar age, abilities, and resources. To date the products of this laboratory range all the way from Plaster of Paris life masks up through office furniture and model boats which perform splendidly, to a real sailboat and a Ford race-about named Cinderella. Numerous things built by members of the Society in other parts of the country have here been tested and constructively criticised.

Members of the Society are given in several ways competitive and financial incentives which are stimulating

(Continued on page 294)

The Engineering Field

Abstracts from the leading professional and trade journals

PHOTOGRAPHING A RIFLE BORE. It has always been desirable to study the deterioration of the surface of the bore of a rifle that results from firing. The rate and manner of erosion is the most important factor in determining the life of a gun.

Up to the present no satisfactory means for making this examination had been devised. For guns of fairly large bore, plaster casts of the interior surface were made and these studied after removal. In the case of the Army Rifle of which the bore is only .30 of an inch in diameter, it was practically impossible to use the above procedure and therefore the barrel was split for examination. This method limited the examination in that the effect of further firings on that particular barrel could not be studied.

At present it seems that the Bureau of Standards has found the ideal solution of the problem by building a camera which photographs the surface of the bore on a strip of motion-picture film. If a permanent record is not desired the surface can be examined by a microscope which is part of the camera. This is all done without damaging the barrel in the least.

The most important part of the camera is a periscope which consists of a long brass tube small enough to slide into the barrel. In this tube are three lenses arranged so as to give an erect image of natural size on the film. At the front end of the tube is a right angle reflecting prism which turns the line of sight perpendicular to the axis of the bore. A tiny electric lamp placed in the bore supplys the illumination for taking the photograph.

The prism is necessarily so close to the bore that a width of only one-sixth of the circumference of the bore can be photographed at each exposure. In making a film the rifle barrel is clamped in the camera and the lamp and periscope inserted. The rifle barrel is moved along on ways by means of lead screw similar to that on a lathe, and the two film reels are so geared to this lead screw that the barrel and film move along at the same rate.

A more recent design has been so arranged that the barrel is also rotated making it possible to photograph the entire surface in one instead of six trips through the barrel. However, this camera has not yet been constructed.

The photographic process has only one disadvantage; namely that the reproduction is in black and white which reduces the contrast. However, a visual examination can be made by removing the film and placing a microscope in the prolongation of the axis of the periscope. By using a microscope with a magnification of from twenty to forty diameters very good results are obtained. The observer can see the small cracks, polished high spots, and even fragments which have been stripped from bullet jackets.

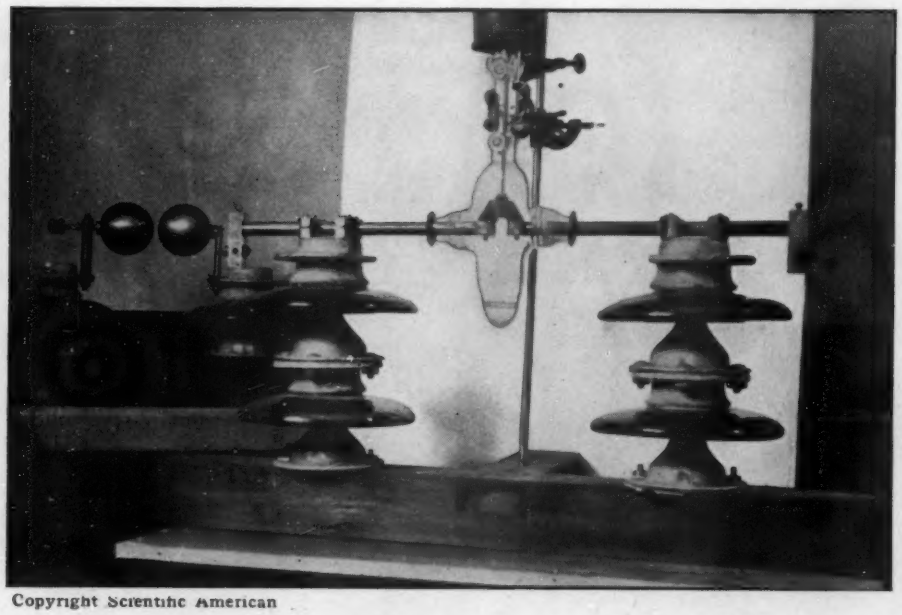
It is interesting to note the appearance of a machine gun barrel at various places along its length. Near the breach the lands are almost worn away, and the bore is filled with a very large number of minute cracks. Midway along the barrel in the bottom of the grooves is a great deal of erosion which decreases along the length of the barrel. Near the breech quite often pieces of metal have been torn from the barrel.

THE LARGEST ELECTRIC SIGN in the world is to be found flashing the name of a popular cigarette nightly above the boardwalk at Atlantic City. The sign has two faces, which are back to back in duplicate, using in all over 25,000 lamps, more than twice as many as any other sign in existence. It measures 215 ft. in length and is 55 ft. in height. The flasher control house is 18 ft. long, 15 ft. wide, and ten feet high. The complete cycle of operation of the display is 75 seconds and passes through all the stages of subdued shades to glaring brilliance. The services of 35 men were required for four months to erect this largest example of modern electric advertising.

8,000 H.P. D.C. MOTOR. What is claimed to be the world's largest d.c. motor has just been completed. It is rated at 8,000 horsepower and weighs 625,000 lbs. The shaft is 26 ft. 8 in. in length and the outside diameter of the frame is 20 ft. Three 50,000 lb. flywheels are used to equalize the peak loads.

Power for operating the motor is obtained from two 3,500 kw., 700 volt generators running at 375 r.p.m.

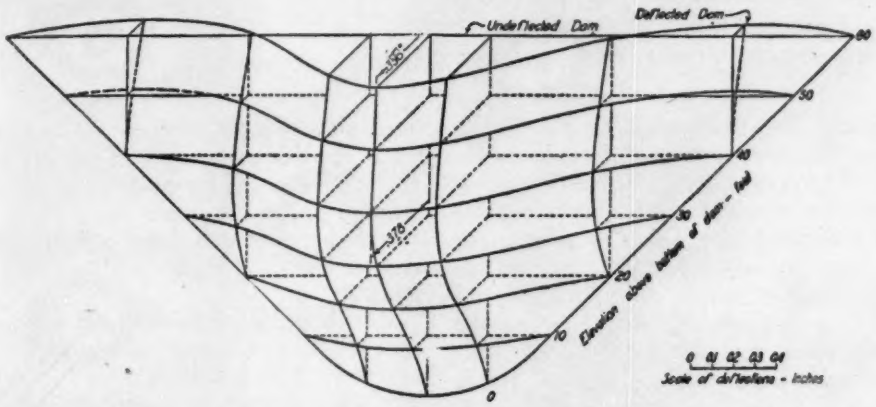
VACUUM TYPE SWITCH. A series of experiments recently conducted at the California Institute of Technology hold forth great promise of the development of a commercially successful vacuum-type switch of extremely small dimensions that will interrupt large currents at high voltages. The switch, which can be held in the palm of one hand, in experimental operation opened circuits carrying a maximum of 926 amp. at 41 kv. Such a development will be very welcome owing to the fact that oil circuit breakers are extremely expensive and not entirely satisfactory.



Copyright Scientific American

PROFESSOR SORENSON'S NEW VACUUM SWITCH

The tube which incloses the switch is exhausted until only one billonth part of the original air remains; this prevents arcing. The switch can handle 1000 amperes at 40,000 volts.


Undeflected Dam
Deflected Dam
Deflection above bottom of dam - feet
Scale of deflections - inches
Test No 11 Sept 19, 1926
60 ft. head of water

Deflections of Dam shown Isometrically on Developed Vertical Face Looking upstream

THE THEORY OF ARCH DAMS is receiving a practical test in the work now nearing completion at the Stevenson Creek Test Dam near Fresno, California. Until the present time, there has been no actual conformation of the underlying principles upon which arch dams are built, with the result that some have been made too thick, and thus too expensive, or too thin, and thus a menace to the surrounding country. In order to obtain some definite information as to the behavior of this type of structure, numerous parties interested in the advancement of engineering in this field have contributed and made possible the building of the dam.

A narrow gorge with sides sloping at an angle of about 45° made an ideal site for the dam, which was completed in the early part of June. It is of the single arch type, with a constant radius of 100 ft., and a height of sixty feet. The work was accomplished at considerable difficulty as the foundation had to be excavated in granite rock, and there was no little interference due to the rolling of loose rocks down upon the damsite. Once the foundation had been prepared, the placing of the concrete proceeded rapidly, requiring in all only forty-six days.

Since the purpose of the work was entirely experimental, a close check was kept upon the quality of all material going into the construction. The average strength of the concrete was maintained at above 2,000 lbs. per square inch for 28 days. Various instruments to show the behavior of the dam under pressure were imbedded in the concrete at pre-determined critical points. Among the most interesting of these devices is the electric telemeter, devised by the Bureau of Standards. It measures the compression exerted at a given point through the variation in resistance of a stack of carbon discs in an electric circuit and operates on the same fundamental principle as the telephone transmitter. Measurements of strain and deflection were also made through the use of various instruments.

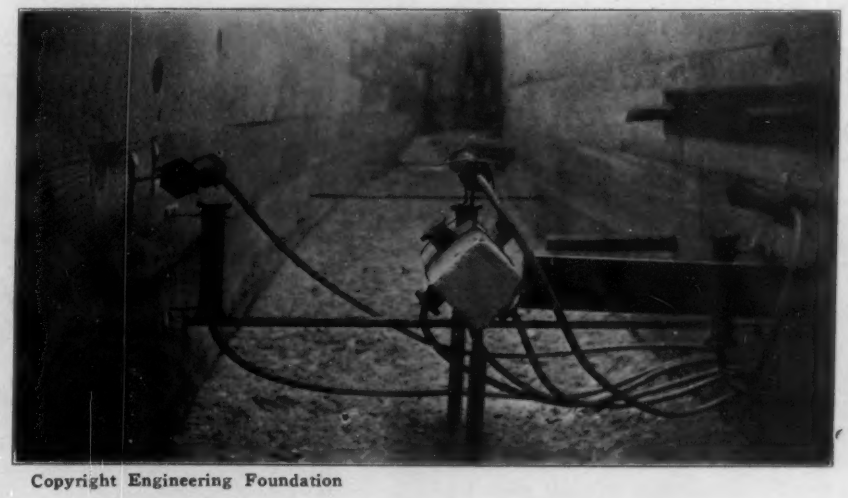
The testing period took place after the dam had thoroughly dried and settled. The reservoir was first filled to a depth of ten feet and the various instruments read and recorded. The reservoir was then emptied and the process of measuring repeated. The same procedure was used at levels of ten foot intervals until the crest of sixty feet was finally reached. The readings were all taken at night, in order that there might be as little temperature change as possible, and the tests were conducted twice at each level in order to insure absolute accuracy of the results.

From every standpoint, the work has proved to be eminently satisfactory. The deflections under pressure as measured directly agree very well with the results as computed from the data obtained by strain gauges. The dam has stood up well, showing no signs of weakness which might point to faulty design or construction. Plans are now on foot, however, to obtain sufficient funds to continue the work by extending the dam to a height of 100 feet, and then testing it to destruction if possible. In this way, it is hoped to complete the entire project and thus afford the various interested parties a wealth of information which might be obtained through no other means.

NEW AUTOMOBILE BRAKE ELEMENT. A new composition brake block has been developed by the American Brake & Foundry Co., which, it is believed, will supersede the fabric brake bands now used on automobiles. These blocks are composed of heat resistant and friction elements moulded at high temperatures. Since they contain no fabric or metal, they will withstand high temperatures without loss of frictional properties.

Due to their high frictional properties, only 20% of the brake drum surface will need to be covered, compared with 60% covered by fabric bands. This enables heat to be more readily dissipated, and the brake parts are more effectively cooled.

TRANS-OCEANIC ZEPPELIN FLEET. If the 6,000,000 cu. ft. dirigible which is to replace the Shenandoah should prove successful, the Goodyear Zeppelin Company will probably build a fleet of similar ships for trans-Atlantic service. The day seems not far distant when commercial ocean passenger service will be a reality rather than a hope for the future.



Copyright Engineering Foundation

TELEMETERS READY TO BE IMBEDDED IN THE TEST DAM

These instruments were designed by the Bureau of Standards and a series of them imbedded in the concrete each time the dam was built five feet higher.

Here and There

Interesting notes from the Editor's desk

SUPPLY AND DEMAND

The electric power plant supplying Wales, North Dakota, was recently involved in an odd situation. The plant had the tremendous output capacity of twenty amperes. But there were eight electric flat irons in the town of Wales, each of which drew five amperes from the line. Consequently the owners of the irons were circularized and informed that they would be allowed to use their irons only in accordance with a schedule, four in the morning and four in the afternoon, in order to avoid injury to the plant or break in the service due to overload.

ENGINEERING ADMINISTRATION PROBLEM

The coal strike in England gave rise to an incident which we believe should be brought to the attention of the students of Engineering Administration. Naturally business boomed for other English fuel companies. Gas companies were the distributors of the now highly valuable coke. One company, whose owner wanted to go to heaven, decided not to turn away any of the mothers with babies, without giving them at least a portion of the coke that they asked for. Babies at once became the most popular institution in England. They were borrowed and loaned and accordingly became one of the factors in Economics. A visitor from a warmer country, not knowing what it means to be cold, would have marveled at the neighborly good will in which English women were willing to "take care of baby for a few minutes." The gas company, not being able to afford an investigating staff to identify repeaters among the babies that were carried by the women purchasing coal, had to modify its announcement that preference would be given to mothers.

DISINFECTANT ACTS BY INVISIBLE RAYS

We hear from "Merk's Report" that sodium hypochlorite, the common disinfectant used in drinking water and swimming pools, does not sterilize by direct contact but by means of germ-destroying invisible rays which it gives off when it comes into contact with organic matter.

On looking more deeply into the matter, our Managing Editor found that the germs were believed to be killed by violet rays. It did not seem probable to him that such rays could be generated in a quantity even great enough to be dangerous to germs. Hence, after much deep thought and prolonged research, he came to the conclusion that the rays merely sunburned the germs so that their backs peeled. The germs, he claims, then died from exhaustion produced by too much back scratching.

BLUE PENCIL

Who says that we never do any editing? Read this sentence as it came to us hot off the typewriter of a stenographer over at the Institute. "..... where the inexperienced personal equation introduces very large areas."!

GETTING OUT A PAPER

Getting out a paper is no picnic.

If we print jokes, folks say we are silly.

If we don't they say we are too serious.

If we publish original matter they say we lack variety.

If we publish things from other papers, we are too lazy to write.

If we stay on the job, we ought to be out rustling news.

If we are rustling news, we are not attending to the business in our own department.

If we don't print contributions, we don't show proper appreciation.

If we do print them, the paper is filled with junk.

Like as not some fellows will say we swiped this from the exchange.—We did.

VERSATILE MINER

After a young mining engineer had spent several weeks in company with an Indian chief and four dogs, prospecting for gold in the long range of Alaskan mountains that borders the Arctic Ocean, the "grub" supply of the party gave out. If they were not soon to starve, a hasty return must be made. Not wishing to sacrifice their valuabe dogs for food it was decided that the Indian, with the few remaining pounds of food, should retrace the journey on foot as far as Arctic Village. The white man would attempt to go by water, and since it would be a down-river journey, he should be able to do without much food.

But how to obtain the necessary canoe? Boat-making materials were not to be had in this barren country. Yet according to the *Scientific American,* a craft of a sort—not beautiful, not especially seaworthy—was hastily made.

The ribs and strakes were of willow saplings tied together with grass. Over this framework was stretched a sort of patch-work or "Joseph's Coat," consisting of the following: one sun-shade, one "parka," one pair of overalls, and one pair of underalls. These sundry garments and fabrics were all sewed together and then daubed with caribou fat in an effort to make them waterproof. The resulting sheet was then attached to the outside of the willow framework.

In this shaky craft the plucky adventurer started on the long trip down the notoriously turbulent Sheenjak River.

After many days of peril and privation, and especially of constant, trouserless battle against the innumerable hordes of mosquitoes that infest the far north, the hungry prospector finally reached the Yukon and a civilized community. For the most part, he says, he was clothed in a black beard and a head-net.

Food was his second request; his first was for a pair of "pants."

FLAKED GLASS

The American Indians used to shape their flint arrowheads by first getting the flint very hot, then dropping cold water on it, causing thin flakes to fly off from the surface. This process has been modified and modernized to produce the flaked glass now so much used for office partitions. The glass surface is first sand blasted to assure the intimate adhesion of a highly tenaceous glue that is next spread over the sheet. The coated sheet is then dried in a slow oven. With proper control of the heat for about twelve hours, it is found that the glue in shrinking has dragged off with it the skin of the glass in the form of thin flakes. This gives to the sheet the flaked effect desired.

—but why choose your life-work that way?

YOU'D laugh at a man who couldn't make up his mind which colors to back. But isn't that about the way a good many men start out on their careers?

All through college the most important study a man can select is himself — to find out by self-analysis and experience what is his particular aptitude and what work he should get into after college.

It's a good rule to talk this over with the faculty and with men out in industry to get all the guidance you can in "finding yourself" — because your whole happiness and effectiveness in your career is at stake.

Published for the Communication Industry by

Western Electric Company

Makers of the Nation's Telephones

Number 63 of a Series

Professional Notes

Activities of the Undergraduate Engineering Societies of the Massachusetts Institute of Technology

AERONAUTICAL ENGINEERING SOCIETY

On the fifteenth of November the Society inaugurated a new branch of its activities by publishing the first issue of the "M. I. T. Aviation News." This publication, which is not for sale but is sent free to all members, consists of a number of mimeographed sheets bound together, and is devoted to the furtherance of the Society's aim of the disbursement of knowledge and the stimulation of interest in aviation. This first issue was naturally somewhat of an experiment, and those in charge were highly pleased with its enthusiastic reception.

During the month of November the Society continued in its plan of holding bi-monthly meetings, and on the 17th were addressed by Captain H. N. Heisen, commander of the East Boston Airport, and Professor C. H. Chatfield, of the Aeronautical Engineering Department. Captain Heisen, who has been in charge here but a few months, explained the workings of the Airport, gave many interesting views of the position of Boston in the air world, and answered numerous questions about the Army Air Service. Professor Chatfield told his version of the 1926 Air Races at the Sesqui, with some humorous sidelights, and ended with a brief survey of the aim and character of Course XVI.

On Wednesday, November 24th, Dr. Von Karman of the Aeronautic Institute of Aachen, Germany, spoke on the recent developments in gliders and the conclusions drawn from them. Dr. Von Karman has for some years been noted for his work in applied mechanics, and becoming interested in aerodynamics has now gained distinction in that field. In his address he explained the aerodynamics of the glider and the advantages of some of the types, illustrating his lecture with a number of slides. Following the talk were two reels of motion pictures of the International Gliding Meets held in France a few years ago, in which the M. I. T. Aero Engineering Society glider was featured as an outstanding competitor.

The dates and speakers of the next meetings have not yet been definitely determined, but several men of fame in the air have signified their willingness to speak when convenient, assuring an interesting program.

EVERARD M. LESTER, '28, *Secretary.*

CIVIL ENGINEERING SOCIETY

The speaker at the Smoker of November 23 was Mr. Abel Stevens, engineer for the Ingersoll Rand Company. His topic was "Explosives," and was given in conjunction with two motion pictures: "The Story of Dynamite," and "Letting Dynamite Do It." These movies were furnished through the courtesy of the E. I. du Pont de Nemours & Co.

Mr. Stevens' talk briefly covered the manufacture of dynamite, precautions in handling of it, its great efficiency and effectiveness in engineering, and interesting examples of its use on work familiar to the speaker. Many questions pertaining to the subject of explosives were asked by members. Professor Spofford terminated the meeting with a short address.

This meeting was very well attended and very promising to the officers of the society in view of coming smokers. The experiment of having a supper, the student paying twenty-five cents and the society bearing the remainder of the expense, proved to be successful, and will be adopted as a regular policy for succeeding gatherings.

One of the most important and interesting of the Chapter's winter smokers is that of the new Metropolitan Water Supply project. It will be an addition to thirsty Boston's present supply and means an expenditure of more than eighty million dollars. A twenty-five mile tunnel is to be driven, a huge storage reservoir must be constructed, and miles of highways and railways must be relocated. Six townships will be submerged by the water which will add 33 million gallons a day to Boston's present consumption. The control survey recently started, consists in throwing a network of points and lines over sixty square miles of settlement. It is a long time job on which many Technology graduates will find employment.

REGINALD F. JACOBS, '27,
Secretary.

CORPORATION XV

Those who have taken an interest in the activities of Corporation XV are rejoicing that the society this year is very much alive, and that it is offering to its members many privileges from which they are deriving educational value as well as entertainment.

At a dinner meeting on November 16, 1926 held in Walker Memorial, Mr. Whiting Williams, counselor of Labor Management, was received with much enthusiasm and interest as he told of his experiences in this country, in England, in France, and in Germany, in the coal mines where he had worked as a laborer in order to study the minds of the workers, and to ascertain their reactions to their work. He stressed the fact that since 85% of the cost of production is labor, why not learn to properly direct labor into channels which will be profitable for the company as well as beneficial to the general welfare of the worker. Mr. Williams praised the work of Course XV in meeting the need of industry for engineers with business training, and urged the fellows to develop themselves into "engineers of human relationships" as well. Mr. Williams who is a Harvard University graduate was introduced by Charles C. Smith '27, president of Corporation XV.

Plans for a combined meeting with the Society of Industrial Engineers to be held in December are in progress, and it is expected that at this meeting valuable relationships will be established with this organization, which in the past has accepted stockholders of Corporation XV into its student membership, with the privilege of becoming junior members after leaving the institute.

As has been customary in past years Corporation XV will make a trip to New York City at the close of the first term examination period for the purpose of visiting various plants and engineering projects. Plans are already rapidly progressing, and there is much interest being shown in this year's trip which promises to be unusually successful. The management invites the cooperation of all the stockholders in making this trip as valuable as those which have been conducted in past years.

ALDEN G. REED, '27,
Secretary.

ELECTRICAL ENGINEERING SOCIETY

Both old and new in the Boston Edison Company's generating equipment will be inspected by the M. I. T. Branch of the American Institute of Electrical Engineers.

The "L" Street Station, formerly

(Continued on page 292)

MAKERS OF POWDERS SINCE 1802

Farming used to be an extremely primitive occupation, before the invention of mechanical farm labor

Facilities

that assure satisfaction

MERELY assembling materials and putting the machinery to work for manufacturing explosives is comparatively easy. However, to produce, out of hand, those intangible and wholly indispensable facilities representing the constant efforts of many years, is a most difficult accomplishment.

The experiences acquired in a century and a quarter of explosive manufacturing and the observations of explosives experts have provided the du Pont Company with adequate facilities to cope with the present demands for explosives. With its plants strategically located and sufficient production assured, du Pont explosives can be specified with entire confidence as to prompt deliveries and satisfactory performances.

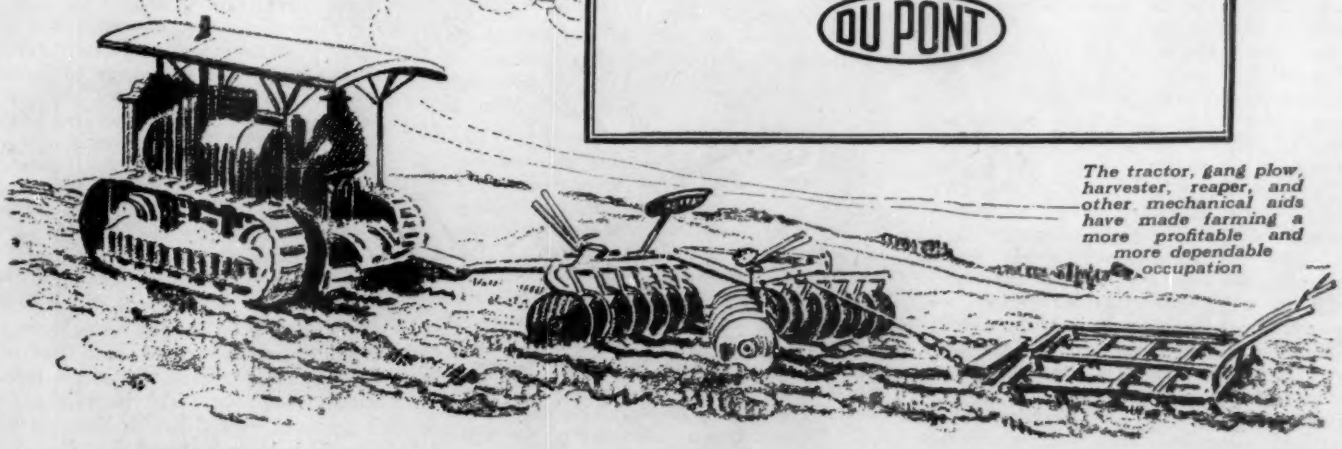
"The Blasters' Handbook" is an authoritative work on the selection and application of explosives to industrial operations. Leading technical institutions throughout the country have placed this handbook in the hands of their instructors and students. You need this handbook. Write for it NOW! It's FREE.

E. I. DU PONT DE NEMOURS & CO., INC.

Explosives Department

Wilmington, Delaware

DU PONT



The tractor, gang plow, harvester, reaper, and other mechanical aids have made farming a more profitable and more dependable occupation

125 YEARS OF LEADERSHIP IN THE SERVICE OF INDUSTRY

Recent Books

This department conducted in co-operation with the Technology Library

Science and Life. By Frederick Soddy, Professor of Inorganic and Physical Chemistry, University of Oxford. 4th edition, 229 pages. New York, E. P. Dutton and Company, 1926.

A volume of a type not generally reviewed on this page, this book proved of exceptional interest. It was written during the period of the great war and shortly afterward, but loses little because of the reprinting.

It is made up of a series of essays and speeches by the celebrated English scientist on the philosophical phases of science. It includes, to be sure, two rather technical chapters on the evolution of matter and modern research in atomic structure, but the bulk of the book discusses such topics as "Chemistry and Natural Prosperity," "Science and the State." "The Future of Science and What Bars the Way," "Matter, Energy, Consciousness and Spirit" or "The Ideals of a Science School," etc.

It is a stimulating book and a very gratifying one to the youth of today. We recommend it highly to student engineers and know that if they read it, they will recommend it as we are doing to their brothers in the so-called liberal arts colleges.

A Collection of Chemical Lecture Experiments. By H. F. Davison, Assistant Professor of Chemistry at Brown University. New York: Chemical Catalog Co., 1926. 139 pp.

Most unfortunately Professor Davison died just as the manuscript was being completed. One of his assistants reviewed it but made few changes so that the book is presented essentially as it would have come from the hands of its author. Professor Davison's loss is keenly felt for he was an earnest sincere teacher, well liked and highly respected by his students and associates. It is due in no small part to his efforts that the study of chemistry at Brown University has assumed its proper importance and that the chemical courses now offered there are on a par with those of the great American Universities.

The book itself is concise and to the point, in keeping with its subject matter for, as the introduction explains, chemical lecture experiments must be simple and short, they must adequately and clearly demonstrate the principles involved and they must never fail to work. The author has always kept these injunctions in mind while describing his experiments. Each experiment has been reduced to its essentials so that it may be performed with the least possibility of failure, and warning is given when delicate operations are unavoidable. In addition, a short explanation of the principle taught is included.

The experiments cover most of the fundamental laws of chemistry as well as many of the applications. The explanations are in accord with the latest knowledge of chemical laws although some may be contested, especially one which states that the absorption of water vapor from the air into concentrated sulfuric acid is due to the fact that the vapor pressure of sulfuric acid is less than that of the water vapor in air.

Although many of the experiments are contained in previous books, there are enough new ones described to make this book valuable in addition to the fact that all included are brought up to date.

The Story of Philosophy, By Will Durant, Ph.D., New York; Simon and Schuster, 1926. 586 pp. Illustrated.

The simple title of this book truly describes its character but naturally cannot inform the reader of the life-giving quality of the story. Here is philosophy brought to life. Philosophy, in these pages, is no longer subjective, but interwoven with the lives of its creators it becomes objective and alive.

The author develops in a clear, easy style the story of the history, content and present state of philosophy, regarding the lives of its creators and moulders as an integral and significant part of the forces guiding its development. One after another, starting with Socrates and Plato, the great thinkers who created Philosophy, are taken up. Their lives and background, their teachings and writings, are brought out and the relations between them made clear. The subject matter and import of their philosophies is made simple and clear, and then criticisms are made and discussed and conclusions drawn.

After Plato come Aristotle and Greek Science, Francis Bacon, Spinoza, Voltaire and the French Enlightenment, Kant and German Idealism, Schopenhauer, Herbert Spencer, Nietzsche, contemporary European and contemporary American philosophers. "Certain lesser figures have been omitted in order that those selected might have the space required to make them live," and those present do live, giving life to this story of the growth of the branch of human thought so bound up with their work and experiences. Yet the treatment of the lives of these men does not assume major importance in the story. They contribute, as told, directly to the development of the philosophies themselves and a clear explanation—perhaps resumé— of their subject matter. The relations of the philosophers to each other is not neglected, and a two page table gives a graphical presentation of this matter. The whole subject is unfolded bit by bit as the author unfolds the rest of the story.

Even for a busy engineer or a layman who is interested in philosophy only because he has met references to it, this book presents a splendid birdseye view with its consequent comprehension, and is fascinating reading.

Petroleum Development and Technology in 1925. Paper presented at the symposiums of Aug. 28, 1925, Jan. 21, 1926 and Feb. 15, 1926 of the Petroleum Division of the American Institute of Mining and Metallurgical Engineers, Inc. New York: Am. Inst. of Min. & Met. Engrs., 1926. 784 pp.

This book is most valuable as a reference work in the field of the technology and its growth, of petroleum development. It covers to the fullest extent the important technologic advances of the petroleum industry in 1925. The contributions are a series of separate papers by separate individuals which were presented at three of the meetings of the Petroleum Division of the A.I.M.E. They are grouped according to subject matter in the volume and thoroughly cover the phases of Production Engineering, Refining Technology, Transportation Engineering, Production and Petroleum Economics. There are included parts of some of the voluntary or unprepared discussion which took place at the meetings, but all parts not contributing directly to a development of the subject of the book have been deleted.

Grouped under Production Engineering are papers on such subjects as Well Spacing, Core Drilling Technology, Improved Production Methods, Deep Well Pumping and Mining Oil Sands. Under Refining Technology is a thorough discussion of Petroleum Cracking by the various methods, its economic aspects and the new anti-knock motor fuels. Production is such an important item that under this heading are grouped a glittering array of papers and discussion by men who know the petroleum game the best.

The book contains the thought and opinions, experience and conclusions of the best men of the industry and should be very valuable as a reference for anyone at all interested in or connected with the petroleum industry either from an engineering or a business standpoint.

Industrial Stoichrometry. Chemical Calculations of Manufacturing Processes. By Warren K. Lewis, Head, Department of Chemical Engineering, M. I. T., and Arthur H. Radasch, Professor of Ceramic Engineering, New York State School of Ceramics at Alfred University. New York: McGraw-Hill Book Company, 1926. 174 pp.

This book is an advanced text designed to effect the transfer of the student of industrial chemistry from ability to solve problems arising under laboratory conditions to an understanding of the method of attack of the problems which arise in the vastly more complicated chemical processes and conditions of industry. Every student of chemistry who meets quantitative analysis learns to apply the laws of the conservation of matter, of the elements and energy, and of combining weights to laboratory problems, but there is a wide variation of surrounding condition between the laboratory and the industry. This volume effectively bridges the gap, and indicates the methods useful in dealing with the complications met.

The first chapter is an introduction to the work, which is essentially a review of the elementary principles of analytical and physical chemistry so presented as to form a working basis for the solution of the problems later discussed. The first problems discussed are rightly those classified under Fuels and Combustion. Next are the problems arising in connection with gas producers. Because of the important and conspicuous part which sulphur plays in the chemistry of industry, Sulphur Compounds are thoroughly discussed. Lime and Cement come next, then the Stoichrometry of Furnace and Kiln design. Metallurgy, Stoichrometry of Plant Design, and Crystallization are the subjects of succeeding chapters. Under Miscellaneous Problems are treated some of the unclassified problems such as measurement of gas flow by dilution, hydrogenation and electrolysis, and the recovery of solvents, a knowledge of all of which is an important part of the chemical engineer's equipment. The book is complete with problems worked out to illustrate points and methods in an unmistakable way, and at the end of each chapter are a set of problems to be worked out by the student.

Transportation

SPEED of aeroplanes at McCook Field, or of motor boats at Detroit, or of automobiles at Daytona Beach, means little except as a phase of development. But the speed of milk trains, meat trains, coal trains, and passenger trains is quite a different thing—it is a necessity.

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Departmental Notes

(Continued from page 271)

majoring in Aeronautics without actually changing their registration to Course XVI.

The new course in Aeronautics aims to give the student a broad training in all branches of engineering, specialization in aeronautical subjects taking place during junior and senior years. The aeronautical subjects given are intended to cover fundamentals and basic thoretical principles with a small amount of practical work, such as aircraft rigging. In addition, students are encouraged to spend their summers in practical work and to take the aeronautical branch of the R.O.T.C. course which gives them actual operating, maintenance, and flying experience.

The graduate work in Aeronautics, which has been going on since 1914, has been gradually expanded, until at the present time it covers most of the specialized subjects necessary for complete understanding of the art, including design and research in both aircraft and their power plants. Fourteen men are registered as graduate students this year.

Although Professor Warner is on leave of absence in order to carry on his duties as Assistant Secretary of the Navy, he remains head of the department, and controls its general policies. His absence has necessitated an increase in the instruction staff, and Associate Professor C. H. Chatfield, 1914, has been appointed to take over a number of subjects which Professor Warner was teaching. Professor Chatfield comes directly from active industry as he was Chief Airplane Engineer with the Wright Aeronautical Corporation. Mr. L. M. Porter, Yale 1924, has been appointed Instructor in the Power Plant Branch of Aeronautics.

One of the chief activities of the Aeronautics staff is the conduct of experimental investigations and research. Some of this is carried on by students in the form of theses, but the major portion is done directly by the staff. The seven-foot wind tunnel is employed almost continuously for research for the Army Air Corps. At the present time this tunnel is in use for investigation of the interaction between propeller and airplane structure, a subject about which little information has been available heretofore. This work has not been completed, but results already obtained show the considerable gain in propulsive efficiency to be realized by properly stream-lining the nose of the fuselage and providing the propeller with an adequate spinner. The four-foot wind tunnel is used for thesis problems and also for the determination of airfoil and model characteristics. So much Government work has been done in this tunnel that it has become something of a standard of measurement, and it is frequently called upon to check the results of other tunnels. Wind tunnel research is under the direction of Mr. Shatswell Ober, 1916.

Research work in aircraft power plants was inaugurated last year under the direction of Associate Professor C. F. Taylor. No published results are yet available from this work, most of the time to date having been spent in obtaining and setting up new equipment. Recently an order was placed for a Universal Single-Cylinder Test Engine from the designs of the National Advisory Committee for Aeronautics. This single-cylinder engine has a bore of five inches and a stroke of seven inches, and is equipped with mechanical devices whereby the compression ratio, the valve lift, and any event in the valve timing can be varied independently, while the engine is in operation. This piece of apparatus opens up a wide field of possibilities for research in the fundamentals of high speed internal combustion engines. Delivery is expected next June, and the engine will bet set up during the summer and preliminary calibration and some data will have been obtained before the beginning of the next academic year.

Another interesting piece of apparatus which has been obtained and set up for Power Plant investigations is a single-cylinder "Delco Light" Plant complete with supercharging equipment and instruments for measuring temperatures, pressures, and quantities of fuel, air, etc. By means of a special Bureau of Standards instrument, indicator cards are being obtained at high speeds with various compression ratios and supercharging pressures. The results of this work should be of considerable interest in connection with the problem of supercharging high speed internal combustion engines.

Another piece of apparatus obtained recently is the Midgely Detonation Indicator which makes comparative measurements of the amount of detonation taking place in a given engine under various conditions.

Instructor Mac Short made a very extensive tour of inspection last summer, visiting many of the important aircraft factories. This trip served to assist in keeping the Department up to date on recent developments in the industry.

Assistant Professor Brown spent most of the summer at the Air Corps Experimental Field, Dayton, Ohio, conducting free flight tests on Army airplanes. Professor Brown has specialized in this kind of work for several years, and has developed several very interesting instruments for obtaining data in flight.

C. F. Taylor

Department of Physics

(Continued from last month)

The equipment of the photoelastic laboratory has been in a large part duplicated to meet the necessity arising from the additional courses which have been offered to the undergraduate students in the Testing Materials Laboratory. The research work upon which the staff and graduate students taking theses are engaged, includes the investigation of the stresses in airplane wing spars and airplane fusilage—in the tubes and sheets of water tube boilers working at high pressures, and in the connecting rods and other parts of internal combustion engines.

A new Radiometric Laboratory has been established and is being equipped by Dr. Stockbarger and his associates. A course in Radiation Measurements will be offered for the first time at the Institute which will cover the analysis of radiation emitted from various sources, the determination of total radiation in absolute units, a comparison of radiometric instruments, such as the thermopile, photoelectric cell, selenium cell, and the determination of the infra red, visible and ultra violet transmissions of various substances, and preparation and calibration of a radiation standard. One of the researches which is already under way in the laboratory is a preparation of artificial fluorite which is being made in an electric furnace, and it is hoped soon to prepare specimens large

(Continued on page 290)

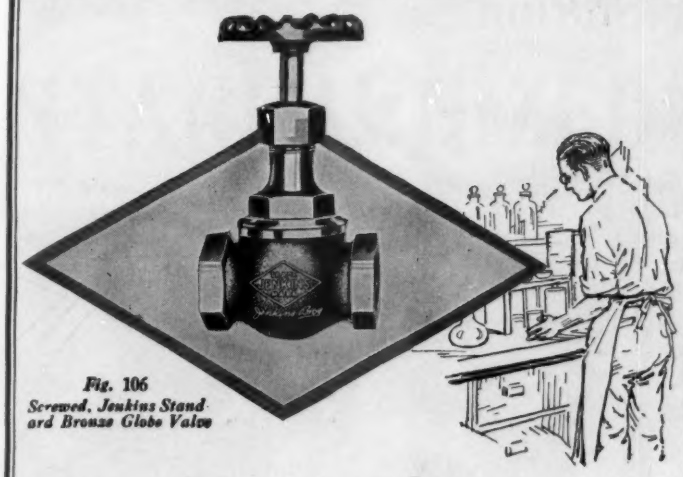

Fig. 106
Screwed, Jenkins Standard Bronze Globe Valve

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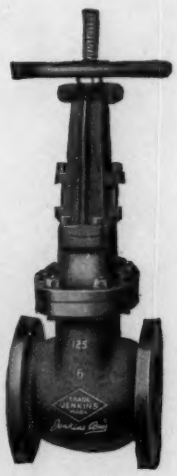

Fig. 651
Flanged, Jenkins Standard Iron Body Gate Valve, with yoke and rising spindle

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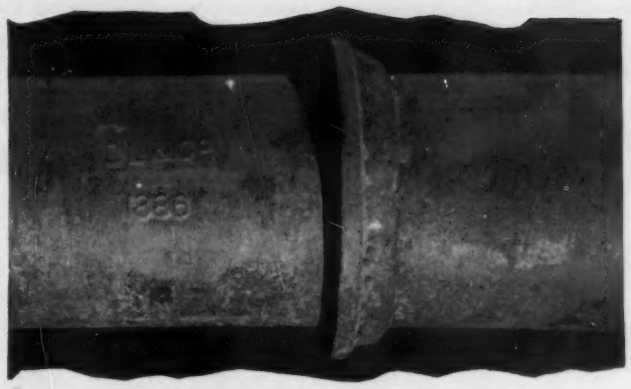

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Steam Power Stations

(Continued from page 267)

method of firing. In the early pulverized fuel furnaces operated with preheated air serious difficulty was encountered in maintaining the brick work. The slag or melted ash ran down the furnace walls either washing the brick away or adhering to it and accumulating in such masses as nearly to pull the furnace walls down. The water wall has practically eliminated all difficulty of this nature. Fig. 2 shows the interior of a pulverized fuel furnace with water cooled walls after a period of operation. Fig. 3 is a cross section of a stoker fired boiler furnace provided with water cooled walls.

While boiler efficiencies in 1910 averaged in the neighborhood of 60%, in the modern plant an average of 80% is not unusual. A case in point is seen in the operating characteristics of the Colfax boiler plant from March 1922 to August 1925. All boilers in the original plant were stoker fired and the increase in efficiency in 1924 was due to starting pulverized fuel equipment in new boilers installed at that time.

The first installation of large air preheaters in this country was made in this station. It was in the nature of an experiment but was successful and demonstrated the economic advantage of air preheating for this plant. It cannot be said that air preheating produces improvements in economy that will justify its use in all power plants. The economic value must be proved in each case and unless the installation will produce a profit above fixed charges equal to or greater than that which would be realized from the same investment otherwise placed the installation is not justified.

The curve Fig. 1 shows the gains in efficiency through the use of preheated air as determined by a series of tests on one of the stoker fired boilers at the Colfax Station. It will be noted that the heat reclaimed from the stack gases represents only about 68% of the total gain in efficiency, the balance being accounted for by reduction in ash pit loss as evidenced by the amount of combustible in the refuse. Improvements of the same general order result when preheated air is used in connection with pulverized fuel. There is always an improvement in combustion efficiency in addition to the saving from reducing the loss due to sensible heat in the stack gases.

A marked change has taken place in the turbine room, both in method of driving auxiliaries and of securing a proper heat balance. In the early days an attempt was made so to proportion the auxiliary equipment as to permit condensation of all of its exhaust steam in heating the boiler feed water. It is practically impossible to secure a balance under all conditions of load and seasonal condensate temperatures by this means as there is an excess of exhaust steam in summer and a deficiency in winter as well as a lack of balance under varying local conditions.

A station of this type produces a kilowatt for 15,930 B. t. u. of net boiler output and if the boiler efficiency were 75% the heat requirement in fuel would be about 20,200 B. t. u. per kilowatt hour. The station is equipped with jet condensers so there is no return of condensate to the boilers. For maintaining a balance under varying conditions exciters and condenser pumps are provided with a combination motor and turbine drive, and by manipulating the load between the motors and turbines the amount of exhaust steam available to some extent can be varied to fit the feed water heating requirements.

In order more readily to obtain a continuous heat balance the house turbine and heat balance set system was developed. With this system a considerable proportion of the auxiliaries are motor driven and arrangements are provided for readily transferring load from house turbine to main bus or vice versa, thus varying the amount of exhaust steam to fit the feed water heating requirements. This adjustment is handled from the main control board by means of a remote control system on the house turbine governor. The operator is guided by feed water temperature and adjusts the house turbine load so as to keep this temperature as nearly as possible at 212° F.

The use of distilled water is liable to cause corrosion and pitting of the boiler surfaces unless special precautions are taken. With an entirely closed system wherein there is no point at which the water can absorb air the oxygen content of the boiler feed water can be kept at a very low value, and corrosion thus greatly reduced. Experience indicates, however, that pure water will pit boiler surfaces even when the oxygen content is practically zero. It has also been found that when water at high temperature is introduced into a boiler drum above the water level the dissolved gases are immediately released and the water passing down to the tubes has no measurable oxygen content. With an entirely closed step extraction heating system wherein the water is heated to 300° or higher little trouble will be experienced from corrosion. In some cases the inside surfaces of tubes and drums have been painted with a special preparation resulting in practical elimination of corrosion and improved condition of the surfaces. Sufficient data is not yet available on which to base a conclusion as to the lasting qualities of this paint but the indications are that it will prove well worth its cost.

The evaporator in the older installation was usually provided with a condenser cooled by the condensate from the main turbines. In the Colfax Station a two effect evaporator was installed with the first two units, taking steam at from 15 to 20 pounds absolute pressure and producing vapor in the second effect at about 3 pounds absolute pressure. This arrangement requires a vacuum pump and condensate removal pumps as well as other equipment to insure its satisfactory operation.

In 1920 and 1921 the value of the regenerative or "stage heating" cycle began to be realized. The term "regenerative cycle" is somewhat of a misnomer, as any system in which exhaust steam is used for heating feed water is in fact a regenerative system. "Step extraction system" would more truly express the meaning. A four-stage step extraction heating system was installed in connection with a 30,000 kilowatt unit in the Colfax Station.

In the Colfax Station the bearing oil coolers, transformers and generator air coolers are cooled with condensate in order to insure clean water. This has no material effect upon the efficiency as the increased temperature of the water flowing to No. 1 heater decreases the amount of steam that can be bled. In other words, if this cooling were done by other means the heat pick-up in No. 1 heater would be correspondingly greater and the total reclamation would be substantially the same.

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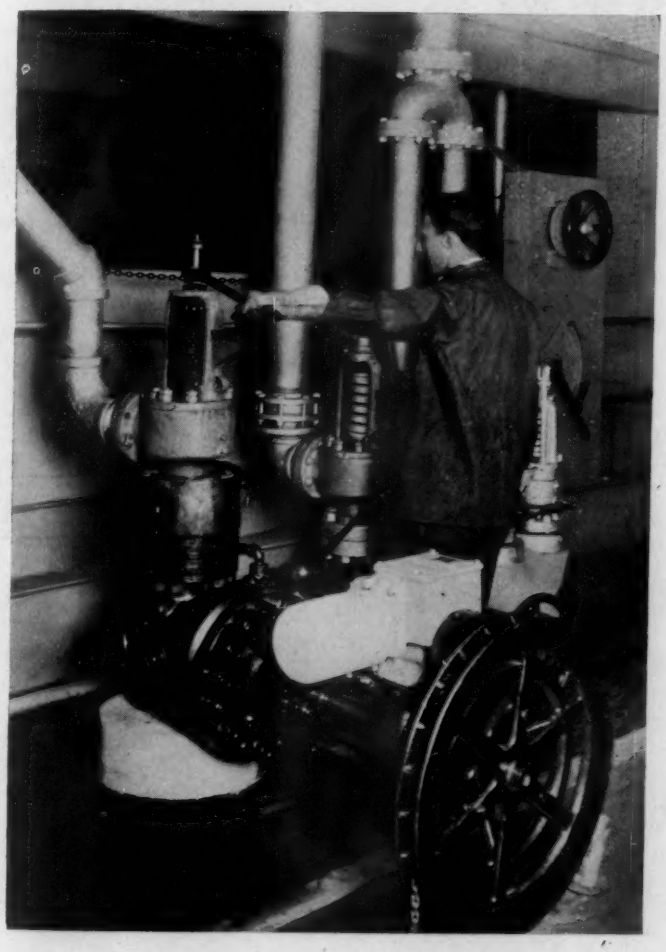

THIS VIEW SHOWS

testing unit of the High Pressure Steam Testing Laboratory of the Consolidated Safety Valve Company, Bridgeport. An actual test is being made of one of the drum valves for the 1200-lb. boiler installed at the Weymouth Station of the Edison Electric Illuminating Co. of Boston.

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Synthetic Methanol and Liquid Fuels From Coal

(Continued from page 262)

ing in succession on the same gas mixture or in parallel.

Here are also photographs of a small plant I have erected in France, of a normal capacity of between 100 and 200 kilograms a day of pure methyl alcohol.

(a) *Production or Extraction of the gas mixture.* On the sketch is represented an ordinary water gas producer because this apparatus can easily produce a convenient gas mixture. But every gas containing carbon monoxide in large enough quantity can be used according to its cost price. All combustible matter can, by incomplete combustion and under definite conditions, give a gas mixture containing enough carbon monoxide to be used in alcohol synthesis. Such is the case for all vegetable plants or their organic residues as straw, wood, charcoal, lignites, bituminous coal, anthracite. The natural mineral oils, as petroleum, can also be used for this purpose. But it must be remembered that the gas mixture obtained from these products should contain only a small amount of unreacting gases (as methane and nitrogen) since a rich gas is better for alcohol synthesis. A high degree of purity is not necessary. The ordinary purification process, as used in a gas works, is sufficient for the synthetic process.

(b) *Compressing the gas mixture.* The compressors form the most important—and the most expensive part of a catalysis plant. Today there are not many constructors having enough experience and knowledge of the technical conditions required for this apparatus to work well at pressures above 250 atmospheres. But through the recent large scale development of the synthetic ammonia industry, the process of working under high pressure is becoming better known every day and it is doubtless that in a short time it will be easy to obtain good high pressure compression apparatus at a reasonable price.

Compression is in many stages; in every stage the ratio of compression is maintained between 3 and 4 to 1. For example a final pressure of 250 atmospheres would be obtained in five cylinders of compression, raising, in succession, the pressure from 1 to 3 atmospheres, from 3 to 9, from 9 to 27, from 27 to 81 and from 81 to 250 atmospheres. A final pressure of 1000 atmospheres can be obtained too in 5 stages by successive compression to 4, 16, 64, 250 and 1000 atmospheres. One of the best methods for this compression is placing the cylinders in tandem with the low pressure cylinder on the stuffing box.

The expense of power can be estimated at 0.36 kilowatt hours for the compression of 1 cubic metre at 200 atmospheres and at 0.5 kwh. at 1000 atmospheres.

(c) *Catalyst chamber.* Generally this apparatus is in the form of tubes constructed of special steel for resisting the high pressure and temperature; the catalyst, in the form of small and regular grains, is disposed in the tube in a special container. The apparatus volume must be calculated according to the working pressure. This apparatus can be heated internally or externally. The second solution is a very poor one because the thickness of the tube walls and their poor conductivity requires, on the external face of the wall, a much higher temperature than inside; steel or metallic alloys lose most of their strength under temperatures higher than 350°C. On the contrary, by internal heating it is possible to keep the catalyst at temperatures as high as 500° to 600°C with the walls at 200°-300°C, a temperature at which ordinary steel retains all its strength and is quite capable of supporting the high pressure with but moderately thick walls. But internal heating is, in the case of alcohol synthesis, more difficult to realize than for ammonia synthesis because the gas mixture will decompose on the red-hot metallic wires, depositing carbon and forming methane. Nevertheless some special arrangements allow this internal heating to be carried out with good results.

(d) and (e) *Condensation and separation of alcohols.* The alcohols are much less volatile than ammonia and it is easier to condense them. A water-cooled coil is good enough, at working pressure above 150 atmospheres, for separating almost completely in a liquid state all alcohol from the uncombined gases.

(f) *Circulation of gases.* For returning the separated uncombined gases (which constitute generally the larger part of the mixture) to the chamber, a circulating apparatus is necessary. This is a delicate problem, due to the high pressure under which the piston must work in the stuffing-box if the apparatus is a piston-pump. Many devices have been tried out in solving this question of a gas-tight stuffing-box under such a high pressure without too great a loss of power. One solution by Casale is to have an injector for the circulating apparatus in which the more highly compressed gas coming from the compressor carries away with it the gas mixture com-

(Continued on page 290)

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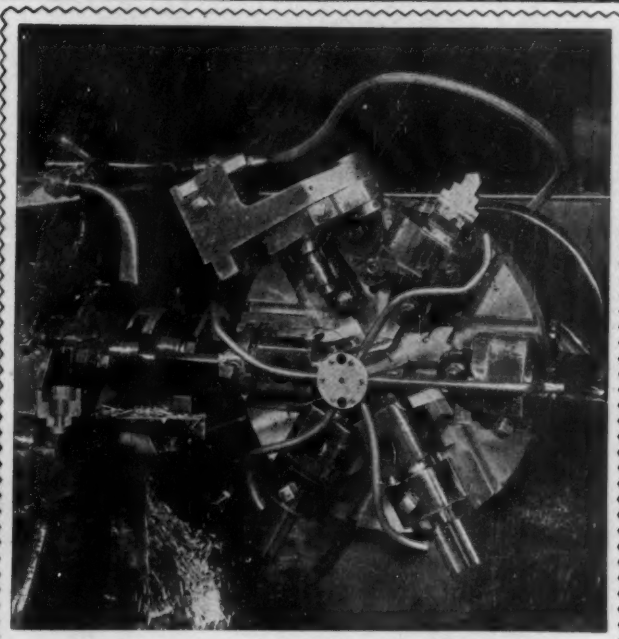

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Methanol

(Continued from page 288)

ing from the condenser. Another solution, from a French contractor, is to interpose a metallic membrane and oil between the gases and the stuffing-box, oils being much less prone than gas to leak through a stuffing-box.

The tubes (generally steel tubes) which form the conduits for the compressed gases are jointed with copper gaskets and are not difficult to keep tight.

VII. *Industrial importance of alcohol synthesis.* From the above indication and description it must be concluded that the synthetic production of alcohols directly from every carbon containing material is a most practical and economical one and does not offer any great difficulty.

By this process can be obtained nearly every alcohol of the aliphatic series, the corresponding aldehydes and most of the acids. Synthetic methanol thus produced has already been put on the market in very large quantities and new plants are now in erection for developing this industry which, in my opinion, may look forward to a very prosperous future.

Departmental Notes

(Continued from page 284)

enough to provide the much needed material for spectrographic lenses and prisms having high ultra-violet transmission. By means of special equipment the laboratory can produce fine wires of unusual materials by extrusion and is at present manufacturing wires of bismuth and some of its alloys for studies of its electromotive force. An investigation is going on of the methods of irradiating cod-liver oil by ultra-violet light. The oil thus treated is tested outside of the Institute by other investigators to determine its antirachitic potency relative to that of untreated oil.

Research is being continued in the development of the mercury vapor lamp. An investigation of the greatest importance relating to the transmission of sound and speech by means of a beam of light from the mercury vapor lamp, has reached a most satisfactory state. Attempts are being made to measure the resonance and ionization potentials of the vapors of the more difficult fusible metals by a new method of procedure.

A laboratory has been set up for research in the field of Electron Theory. Spark discharge phenomena, measurement of ionization potentials, problems of conduction in gases in general, thermionic emission, and photoelectric emission, are among the problems for which the laboratory is intended.

There are accommodations at present for at least six investigators and three students are already at work. Their problems include the amplification of very small currents with a special two-grid tube, the discharge in gases with short gaps and the secondary emission of electrons due to positive ion bombardment.

This laboratory is in charge of Professor Page who has associated with him Doctors Knobel and Frank.

Members of the staff are serving as advisors to some of the large publishers upon technical and scientific matters with special reference to the devices, apparatus and machines advertised in their columns.

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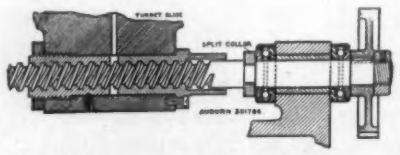
Professional Notes

(Continued from page 280)

the base load station of Boston, will be visited by the Branch this month. This is the largest steam central station in New England. Its successor as base load station, the new Edgar station at Weymouth, will be visited by the members of the Electrical Engineering Society, later in the season. At this latter station is located the 1200-pound-pressure turbine which received so much space in the technical press at the time of its installation. Examination of the high pressure steam piping in use on this turbo-generator was made by the X-ray Laboratories of Technology.



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In a trip to the New England Telephone Company's downtown building housing the manual exchanges, Beach and Dewey, and the triple machine switching unit, Liberty, Hancock, and Hubbard, a similar opportunity for comparison of earlier and later types of apparatus in actual operation will be afforded. Liberty was Boston's first "dial type" exchange and was installed in 1922. Hubbard is only now being built and will not go into operation until some time in 1927. Over 250,000 calls a day are handled by Liberty and Hancock at present.

"The King of the Rails," a movie featuring the system of the longest electric railway in America, The Chicago, Milwaukee and Pacific, which recently changed hands and consequently its name from the C.M. and St. Paul, was shown on November 23 to the Society.

Park D. Manbeck '15, development engineer for the National Carbon Company, spoke on "Application of Carbon Products to Industry" on November 29. He illustrated his talk with the three reeler "Behind the Pyramids" which did not offer the insight into the harem life of Egyptian sheiks that the advance posters had made us hope for, but was more relevant to the subject of the evening.

Dean Dexter S. Kimball of the College of Engineering at Cornell University, and Past President of the American Society of Mechanical Engineers, addressed the Boston Section, A.I.E.E. on December 7. As usual, many from the M.I.T. Branch were present.

The first of a series of student papers was delivered before the Society on December 14. S. W. Marshall, Jr. its author, presented it, illustrating with appropriate lantern slides.

Professor W. H. Timbie, M.I.T. Branch Counselor, has been appointed Chairman of the Student Activities Committee of the Northeastern District, A.I.E.E., which includes all of New England and New York State except the New York City local district.

EDWARD A. MICHELMAN, '29,
Secretary.

NAVAL ARCHITECTURE SOCIETY

The policy of the Massachusetts Institute of Technology Naval Architecture Society has been to run inspection trips to the various points of interest around Boston. The high point in last year's activity came with the visits to the launching of the aircraft carrier "Lexington." Thru the efforts of Captain Snow (now Rear Admiral Snow) who was formerly stationed at Tech, the Society was enabled to inspect the launching arrangements several days before the launching as well as to be present at the launching itself. Another trip was made to the Fore River Plant of the Bethlehem Shipbuilding Co. to look over the general arrangement of the yard and the machinery used. The Argentine battleship "Moreno," which had just undergone extensive reconstruction at Fore River, was boarded at the invitation of the Argentine officer in charge, Tech graduate of Course XIII. A trip was made to the "Boston" of the New York to Boston run when she was in drydock at the Simpson Plant in East Boston.

This year this same policy is to be continued and perhaps extended to include a broader range of subjects. Trips to several manufacturers of machinery and power plants are projected. The Society expects to visit the Sturtevant Co. who manufacture small turbines of the type used to drive auxiliary machinery on shipboard. The Worthington Pump Co., who make auxiliary pumps, con-

(Continued on page 294)

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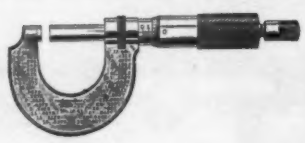

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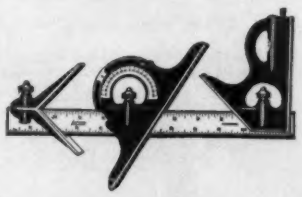

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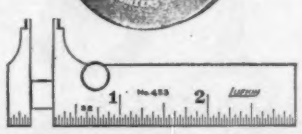

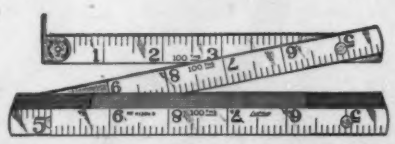

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Professional

(Continued from page 292)

densers, and a few Diesel engines will also be seen.

It is thought that an inspection trip to the Edgar station of the Edison Electric Co. at Weymouth will be made. While land power plant practice is not identical with marine practice, it is possible that some of the many refinements found in the power house can be adopted for use on shipboard.

R. H. TINGEY,
Secretary.

LARGEST MINE VENTILATING fan in the world is being installed at The British Government Mines in South Africa. The fan and engine are designed to give a maximum discharge of 900,000 cu. ft. of air per min. under a 7 inch water gauge. The fan is 30 ft. in diameter and will run at 125 r.p.m. which is equivalent to a per peripheral speed of 196 ft. per sec. The engine develops 1,500 H.P. at the stated speed and is of the tandem compound condensing type.

Editorials

(Continued from page 275)

in the highest degree to those three most desirable qualities, ingenuity, skill and diligence. Several special awards of two dollars each are made each week to the boys who have completed some project of special merit and sent in photographs and building instructions which are published. There is one weekly award of five dollars and there is a yearly award of a four year college scholarship.

The first scholarship has already been awarded. The fortunate boy, Albert F. Bird of Somerville, Mass., is now in his first year at Technology, registered with the department of Naval Architecture and Marine Engineering. He won the scholarship with some really beautiful work in building ship models.

For countless boys this Lab may be an insurance that they will find early enough and definitely what line of work they will want to follow through life because it specializes in discovering, recognizing and fostering the too often neglected creative desire struggling in them for expression.

The only other attempts that we know of to cater to this creative desire were for older men who had "hobbies," and these attempts have always quite neglected any personal element there might be. Business men and engineers have discerned in the Y. C. Lab idea a means of discovering and developing youths of initiative, resourcefulness and perseverance. We look to it for all these results and something more—the guidance of young men into their natural lines of endeavor in society, thereby reducing the overflowing ranks of sad misfits so evident even as early as the first year of college.

A CORRECTION

In our October issue an error was made in giving credit to The Lebanon Steel Corporation for cooperation in furnishing us with photographs. This should have read Lebanon Steel Foundry. We take this opportunity to make the correction.

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Without the precise knowledge and experience of the Explosives Engineer, dynamite may be a wasteful and uncertain force; and waste and uncertainty are costly. Leaders of the mining, quarrying, and construction industries are realizing this more and more. They are looking for men who can eliminate waste and uncertainty in their blasting.

As an aid to engineering students who would like to fit themselves for this new branch of engineering, the Hercules Powder Company has issued many booklets dealing with explosives and the technic of their use; these are yours for the asking. *The Explosives Engineer* is a monthly publication dealing with blasting and allied subjects. Each issue contains information of interest and value to the engineering student or graduate. Mail the coupon on the right for a free sample copy.

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Advanced Boiler Practice

(Continued from page 259)

atomization, however, is only suitable for small installations where the boilers are individually not over 400 H.P. Above this rating mechanical atomization is preferable and for boilers which are to be crowded much beyond their capacity mechanical atomization will enable a higher efficiency to be obtained with overload than it is possible to obtain with steam atomization. With powdered coal as fuel it is still an open question in the minds of many engineers whether for a large sized plant a central crushing and pulverizing system should be maintained or whether the boilers should have what are known as unit pulverizers.

In the preparation of coal for powdered coal burning, following a preliminary crushing to the size of an egg tramp iron is pulled out with a magnetic separator, then follows a drying process, and after drying, the final crushing and pulverizing. A large part of the coal should be pulverized so that it will pass through a 200 mesh sieve,—the power required in the preparation of the coal being 20 to 30 Kilowatts per ton according to the coal handled. Powdered coal fires, like oil fires, can be manipulated quickly and with properly designed furnaces, boilers have been run at 1500% of their rating. With certain grades of coal it is necessary to make use of a special ash-pit from which the fused slag can be easily removed or to put in a water screen in the shape of a series of horizontal tubes, connected with the water surface of the boiler, the tubes chilling the molten slag so that when it settles in the ash-pit it is sufficiently cooled so that the particles of slag do not stick together. Ash-pits have been constructed having a bottom floor covered with hollow rectangular cast iron blocks surrounding tubes through which water circulates. The fused ash striking these cold blocks gets chilled instantly and usually can be removed without any difficulty.

In the Middle West where the coal is of the nature of a lignite it has been found that a chain grate stoker is preferable to the underfed stoker, this stoker being best suited to the better grades of bituminous coal. In as much as a lignite can be burned as powdered fuel about as successfully as bituminous coal, many of the large power stations which are located midway between the lignite coal fields and the Virginia coal fields, have put in powdered coal outfits as they can then burn a good grade or a poor grade of coal equally well.

While fuel oil is still used in some of the large plants it is probable that few of the plants which are now building and which are likely to be built in the near future will be designed for oil burners. I am referring of course to plants not adjacent to the oil fields. The price of oil varies in such a way that there is not much difference in the cost of 1000 lbs. of steam as generated by oil or by powdered coal, and there is in connection with oil always an uncertainty as to the price and as to the surety of delivery. Some plants which have shifted from underfed stokers to oil have been caught in the middle of the winter without sufficient oil to operate and with no possibility of getting oil. In such cases it has been necessary for such plants to install unit pulver-

(Continued on page 298)

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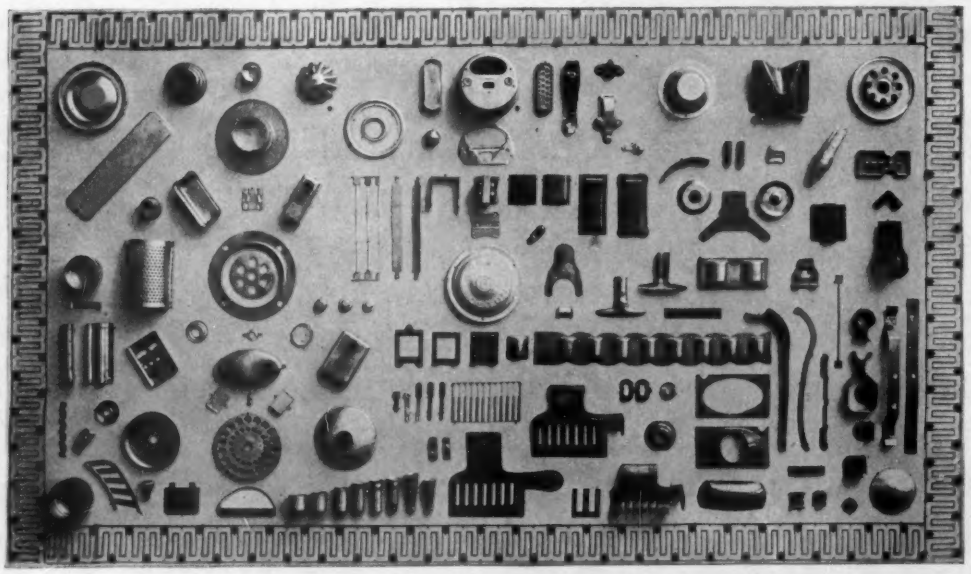

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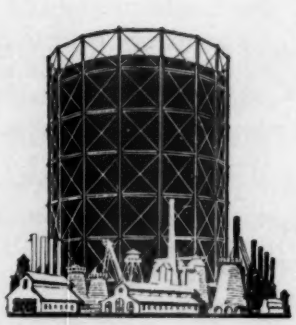

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YOU CAN DO IT BETTER WITH GAS

Boilers

(Continued from page 296)

izers which could be used to supplement the oil-burning equipment.

Engineers have learned more about combustion in the last ten years than in the thirty years preceding. As a result, furnaces, boilers, and economizers have been changed and are constantly being changed. Probably there has been more development in steam generating equipment in the last five years than in any other line of power plant engineering.

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Radiography

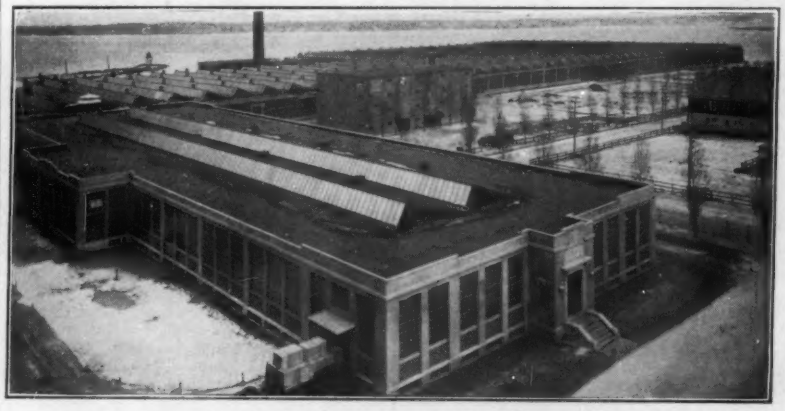
(Continued from page 265)

use X-rays for examining the first or "pilot" casting from each new mould or pattern. The method is considerably cheaper than the method of sawing up now in vogue and is quite as positive in its indications. If the pilot casting proves defective, the causes of the defects can usually be determined and the proper changes made in the casting technique to correct it. In this way, the radiograph may be made to serve as a method of foundry control and the output of sound castings materially increased. This method has been developed by Dr. H. H. Lester and used quite extensively by him at the Watertown Arsenal.

The use of X-rays to study the soundness of welded joints seem to have some very interesting possibilities. The use of the various kinds of welding methods in all sorts of fabricated structures is becoming increasingly important and would be much more so could the soundness of the welds themselves be depended upon. It is quite simple to make a weld which looks nice on the outside and yet be perfectly worthless as far as strength is concerned. A radiograph of a welded joint will give much evidence as to its soundness or lack of it, showing definitely inclusions of gas and slag, seams of oxide, lack of fusion between the plates, shrinkage cracks and so on. It also has the advantage that the particular weld examined is not injured by the examining process and may be put in service if desired.

Much has been said about the advantages of the radiographic method and perhaps it would be well to mention some of its limitations. There are definite thickness limits of the various materials which can be penetrated with the maximum voltages now available. These are about 3 1/2 inches of iron or steel, 2 1/2 inches of brass and about 6 inches of aluminum. Furthermore, there is a minimum difference in thickness which is observable on the film and this is about 1/32 of an inch in 3 inches of steel. This means that a hole smaller than this could not be seen. Fine cracks are also difficult to see unless they are in a plane which is nearly parallel to the direction of the X-rays. A radiograph also tells nothing about the crystalline structure of the object nor the stresses which may exist in the interior. But in spite of these difficulties, the method seems to have much to recommend it. It seems as if we may look forward to much higher voltages and more sensitive detecting devices and that the method will develop many new and useful possibilities.

Technology is fortunate in possessing a very completely equipped radiographic laboratory with some of the most up-to-date equipment available. This laboratory is in the department of physics and the X-ray apparatus is capable of operation at voltages between 25,000 and 250,000. This latter value is the highest for which X-ray tubes are at present available. The work of the laboratory, in addition to that of instruction, includes research on the radiography of various kinds of material and the development of the details of radiographic apparatus and technique.



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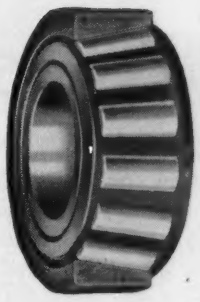

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Chemistry in Power Generation

(Continued from page 269)

generation of a horsepower hour whereas at present the most efficient generation of the same power required only ¾ pounds of coal—a saving in fuel of 40%. This increase is due not only to the solution of related chemical problems but also to much ingenious mechanical development. The chemist contributed, however, a better understanding of the chemical process of combustion and aided in the development of the combustion control methods which are largely responsible for the increase in efficiency. The opportunities for further increase are shown by the fact that the maximum efficiency of standard methods of releasing energy in the form of mineral fuel to energy available at the switchboard is probably not over 28%.

In the constant effort to increase efficiency several central stations are operating at steam pressures of 500 pounds per square inch and upward. Special equipment and alloys were necessary for such practice and in the development and application of these, chemical engineering played an important part.

One of the outstanding recent developments in combustion has been the increased use of pulverized coal. This is shown in Figure II. There are several points of dissimilarity between the combustion of coal on grates and in the pulverized condition. The fuel engineer made noteworthy contributions both on the theoretical side and regarding the practical application of pulverized coal as an industrial fuel.

Further improvements may be looked for in such radical departures from current practice as are illustrated by the use of two boiler fluids in conjunction. The pioneer effort of this type is the plant at Hartford, Conn. in which fuel is burned under a mercury boiler to produce mercury vapor at moderate pressures which is passed through a turbine, where power is extracted, and then condensed under such conditions that steam is produced to be used in turn for power generation in the usual manner. This two fluid process has possibilities of generating power with smaller fuel consumption. One of the principal difficulties in the way of wide adoption of the mercury-steam combination is the relative scarcity of mercury. It has been proposed that various high boiling organic liquids might be substituted. The discovery of such compounds and the development of methods for their preparation in quantity and of requisite purity is a problem which will require the highest type of technical talent among chemists.

Gas Manufacture

Another development which is being intensively studied is the combined gas and electric plant. This plan involves the low temperature carbonization of coal—possibly in pulverized form—to remove light oils, tar, and gas, followed by combustion of the solid residue for the generation of electrical power. The gas would be distributed as at present and the oils would be processed for use as liquid fuels. The quantity of the latter would be only a small part of our total liquid fuel requirements and there are other difficulties such as the dissimilarity of the load factors on

(Continued on page 302)

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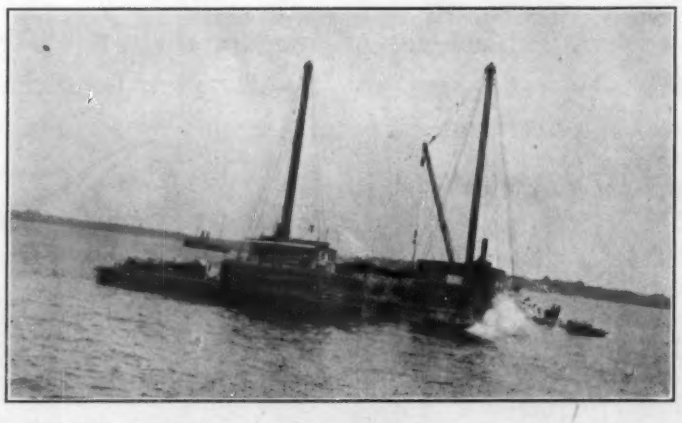

View showing Lighters Nos. 1 and 4 discharging stone from barge at Coney Island, New York, for proposed breakwaters in connection with Boardwalk Contract. 100,000 tons of granite placed in 13 jetties.

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Chemistry in Power Generation

(Continued from page 300)

the gas and electric units of such a combined plant but for base load conditions this plan would undoubtedly result in increased overall thermal efficiency. The solution of this problem rests mostly with the chemical engineer.

The electric super-power unit involving several central stations interconnected to permit increased operating efficiency is now quite common. On the other hand city gas is now manufactured almost exclusively within a short distance of the point of consumption. The super-gas plant—located on the seaboard using coal brought by water transport—may well be considered a possible development when more effective means of high pressure gas transmission are developed. Another possibility is the construction of large byproduct gas plants located at the mine mouth with a similar distribution system. Chemical engineers again are responsible for the major developments in solving these problems.

Development in the Field of Automotive Power

Turning from the production of industrial power to generation of power in the automobile the effect of chemical research is no less evident. The importance of chemistry in the refining and cracking of petroleum to supply fuel for this rapidly expanding industry has been referred to. In the efficient utilization of gasoline the influence of chemistry is no less marked. It is well recognized that increased efficiency in the gasoline engine is attainable by increasing the compression ratio of the gasoline-air mixture. The limiting factor to this increase is the tendency for the fuel to detonate with resulting loss of power and deterioration of the engine. Extensive chemical research demonstrated that this tendency to detonate could be greatly reduced by the addition of such compounds as aniline, iron carbonyl, and tetraethyl lead. The use of these anti-detonating compounds is resulting in the design of smaller motors operating at higher speeds and higher compression ratios. The reduced engine weight greatly affects the entire chassis design. The effect on fuel consumption is remarkable. It is estimated that the development and introduction of anti-detonating compounds such as tetraethyl lead will permit a saving of 40% of our gasoline consumption. This one chemical development alone may therefore result in a saving to this country of over $800,000,000 yearly.

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This discussion has emphasized the part which chemical science has played in the rapidly occurring series of changes which have characterized the generation of power during the past few years. The lines of research leading to the solution of future problems in this field have also been indicated. It should be stated, however, that past improvements have been made only through progress in mechanical and electrical engineering, physics, chemistry and metallurgy. The fundamental importance and basic character of fuel utilization and power generation now calls for the closest cooperation of all branches of engineering and science. The broad scope of this field is leading even to specialization—the fuel engineer. European nations have established great fuel research laboratories. While such effort in the United States is not as highly centralized as abroad, both Institutional and Government agencies in this country are vigorously prosecuting investigations to the end that our fuel resources may be so utilized that our industrial development may continue unhampered.

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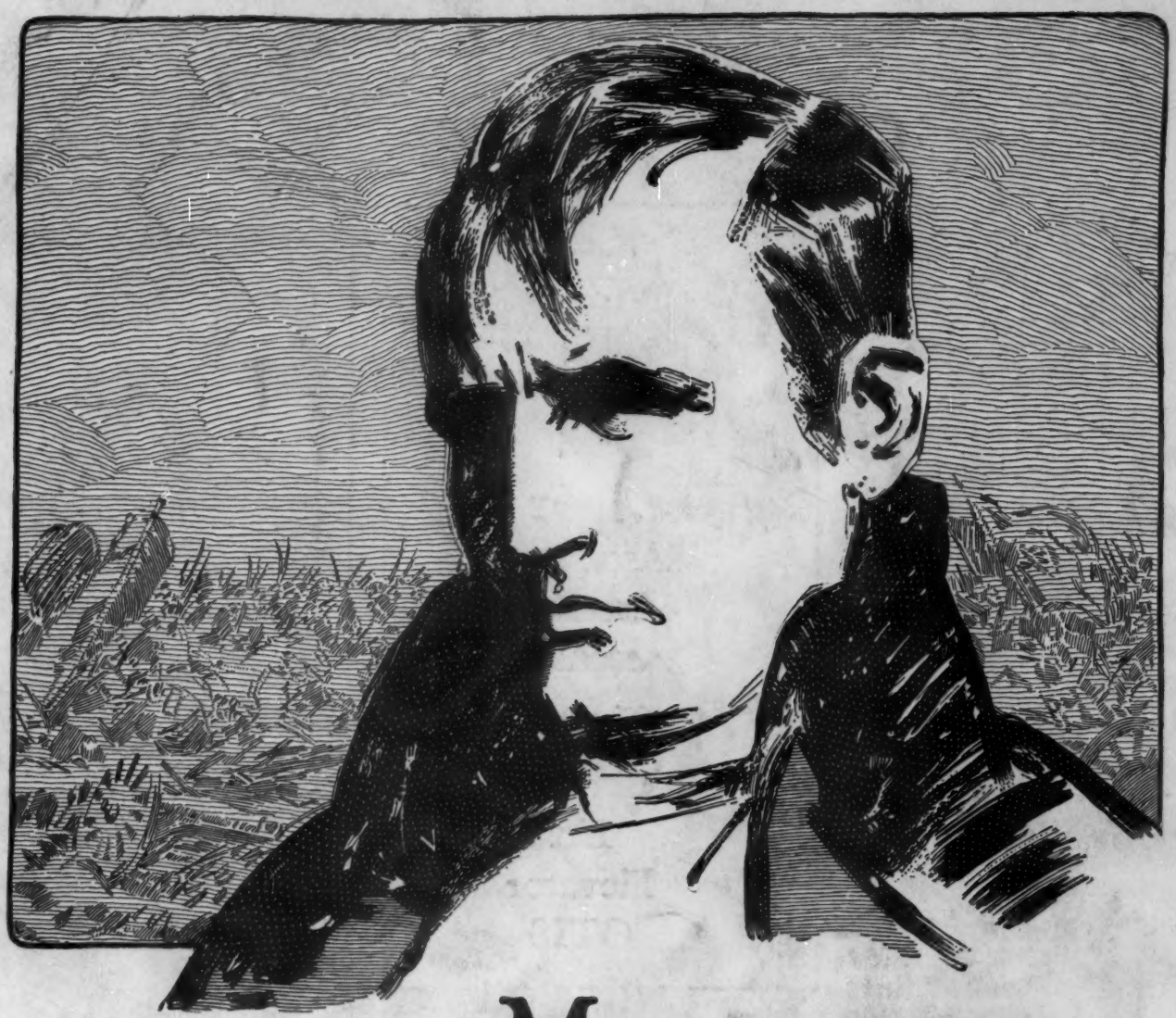

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